MINES AND MINERAL RESOURCES OF MONTEREY COUNTY, CALIFORNIA

COUNTY REPORT 5

CALIFORNIA DIVISION OF MINES AND GEOLOGY

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BY

EARL W. HART

California Division of Mines and Geology

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ABSTRACT

Monterey County encompasses a 3,324-square-mile area that lies totally within the Coast Ranges. Its rugged terrain is accented by the Santa Lucia Range which rises abruptly from the Pacific Ocean to an elevation of 5,844 feet. The broad, alluviated Salinas Valley separates that range from the Gabilan and Diablo Ranges to the northeast. Although the region is quite mountainous, agriculture is the foremost industry, accounting for well-over $100,000,000 production yearly. Other important industries include mining, and manufacturing based on agriculture and mining. The county also is noted for its natural beauty, early California history, and culture. Most of the 198,824 inhabitants are concentrated in the Salinas-Monterey Bay-Carmel Valley area where the climate is quite mild.

The geology is typical of the southern Coast Ranges, being structurally and stratigraphically complex. Pre-Cretaceous metamorphic rocks of the Sur Series probably are the oldest rocks in Monterey County and these have been intruded by Cretaceous granitic rocks. This metamorphic-granitic complex is confined to the fault block between the northwest-trending San Andreas and Nacimiento-Sur fault zones. The Franciscan Formation and associated rocks of probable Late Jurassic and/or Cretaceous age comprise the oldest rocks of the flanking fault blocks. Overlying the "basement" rocks of the three fault blocks are a wide variety of sedimentary formations and some volcanic rocks laid down during the Cretaceous, Tertiary, and Quaternary Periods. The rocks of the region have been subjected to strong structural deformation, resulting in the formation of important northwest-trending, right-lateral and high-angle reverse faults. Folding also has been intense in some areas but is manifested on a smaller scale.

The most important mineral-bearing formations include the Sur Series (dolomite, limestone, barite); Franciscan Formation (gold) and related serpentine intrusives (chromite, mercury, asbestos); Cretaceous granitic rocks (stone, feldspar); Miocene sedimentary formations (oil, gas, coal, dimension stone, diatomite); and Quaternary alluvium, beach and dune deposits (sand, gravel, clay). Although not a formation, seawater also provides an important source of magnesium compounds and salt. Some of the mineral deposits also are directly associated with structural features, being related to faults (gold, mercury) and folds (oil, gas).

The total recorded value of minerals produced in Monterey County from 1889 to 1964 amounts to $386,704,916. In 1964, the value of minerals produced was $29,120,767, ranking the county tenth in annual production among California's 58 counties. Mineral production in Monterey County has been valued at more than $15,000,000 every year since 1952, reaching a peak production of $33,372,321 in 1957. Of the total value of mineral commodities produced, mineral fuels have accounted for 60%, non-metallic minerals for 39% and metallic minerals for 1%.

More than 20 mineral commodities have been produced economically in Monterey County since 1889. Crude oil and natural gas, valued at $232,089,061, comprise the most important group of commodities even though commercial discoveries were first made in 1947. Virtually all of the oil and gas is obtained from upper Miocene sands of the San Ardo field.

Crystalline dolomite, dolomitic lime and magnesium compounds form the next most important group of commodities. The dolomite, which occurs in the Sur Series at Natividad, is used, both raw and calcined, for refractories, roofing granules, plasters, agriculture and other uses. A large amount of dolomitic lime also is shipped to Moss Landing where it is reacted with seawater to obtain magnesium hydroxide, a fundamental raw material used in the manufacture of a variety of basic refractory products.

Sand and gravel constitute the third largest group of mineral commodities with an annual production of well over two million dollars in recent years and a total production of approximately $50,000,000. Common construction sand and gravel are obtained mainly from stream channels and Recent beach and dune deposits. Specialty sands (including silica and feldspar products), which are more important value-wise, come from Recent dune deposits on Monterey Peninsula and beach and dune deposits along Monterey Bay.

Crushed, broken and dimension stone for non-industrial purposes has been moderately important with total production amounting to nearly four million dollars. Other non-metallic and fuel commodities, named in order of decreasing total value are salt, coal, limestone and lime ($516,497), diatomite ($473,645), mineral water ($67,000), clay materials ($60,023), feldspar (pegmatite only), barite, gem stones ($3,883), bituminous sandstone ($2,710) and asbestos.

The metallic minerals account for only one percent of the total mineral production in Monterey County. Mercury, most of which came from the Parkfield district, leads the metallic minerals with a production of $200,011.

Gold and minor amounts of associated silver were produced almost entirely in the Los Burros district. The modest recorded production of $104,776 came mainly from the Last Chance and Plaskett lode mines and the Willow Creek placers. Chromite is the only other mineral produced commercially, total production being $70,579. Practically all of the chromite ore was obtained from the South Slope mine near the Los Burros district.

MINES AND MINERAL RESOURCES OF MONTEREY COUNTY, CALIFORNIA*

BY EARL W. HART

Introduction

PURPOSE AND SCOPE

The present report is a comprehensive review and appraisal of the mineral resources of Monterey County. Since publication of previous mineral surveys by Irelan in 1888, Waring and Bradley in 1919, and Laizure in 1925, the mineral industry has changed greatly and mineral production has increased in value 100-fold. Therefore, a particular effort was made by this writer to record the historical changes that have taken place since 1925. The principal emphasis of the present study, however, is directed toward the evaluation of the mineral resources on the basis of current knowledge and technology.

The individual mineral commodities considered to be of value at one time or another in Monterey County are summarized, each summary being followed by discussions of the significant mineral deposits and operations. Less important deposits and prospects are briefly described in a tabulation at the end of the report. Because a knowledge of geology is of inestimable value in the exploration for and development of mineral resources, the relationships between the mineral deposits and geology is stressed throughout the text and on the geologic-economic map. It is hoped this report will be used not only as a guide to mineral prospecting and development, but also as a reference for local and regional planning.

METHOD OF INVESTIGATION

The task of investigating the mines and mineral resources of Monterey County was assigned to this writer in early 1956 and work was initiated in December 1958. Field examinations of the active and principal inactive mineral deposits and processing plants were conducted mainly during 1959 and 1960. At that time, information on the mineral deposits also was obtained from representatives of the mineral industry and government agencies, as well as individual geologists, engineers, prospectors, property owners and residents of Monterey County. In addition, a large amount of data was obtained from the existing literature, as well as from a few consulting and other unpublished reports.

Based on the field examinations and published and unpublished data, a final draft of the report was completed in February 1962. This was reviewed by the author's supervisor, Oliver E. Bowen. Another comprehensive review was made during 1962-1963 by Fenelon F. Davis, the Division's Supervisor of County Report projects. Partial reviews were made by other geologists of the Division of Mines and Geology, including Salem J. Rice, Harold B. Goldman, Frederic R. Kelley and William B. Clark. Revisions based on the several reviews and on new publications were made between August 1962 and June 1963. Only minor changes have been made since then, although the statistics were updated through 1964.

This writer wishes to extend his sincere appreciation to all of those individuals, companies and agencies who provided information or otherwise cooperated to make this report as complete and accurate as possible. I also wish to acknowledge the assistance of those of the Division of Mines and Geology staff who typed, drafted, reviewed and edited this report.

GEOGRAPHY

Monterey County has played an important role in the early political and cultural development of California. It was first explored in 1602 by Viscaino, who named Monterey Bay in honor of Conde de Monterey, then Viceroy of New Spain (Gallagher, 1958, p. 981-984). The first settlement was located at Monterey in 1770 when the Carmel Mission and Presidio of Monterey were established (although the mission was re-established in Carmel the following year). In 1776 Monterey became the capital of Alta California. After California was admitted to the United States, Monterey was one of the original 27 counties created in 1850.

Between 1850 and 1873, Monterey County's boundaries have been changed 4 times and at one time

* Manuscript submitted for publication July 1963. Statistics partially revised through 1964.

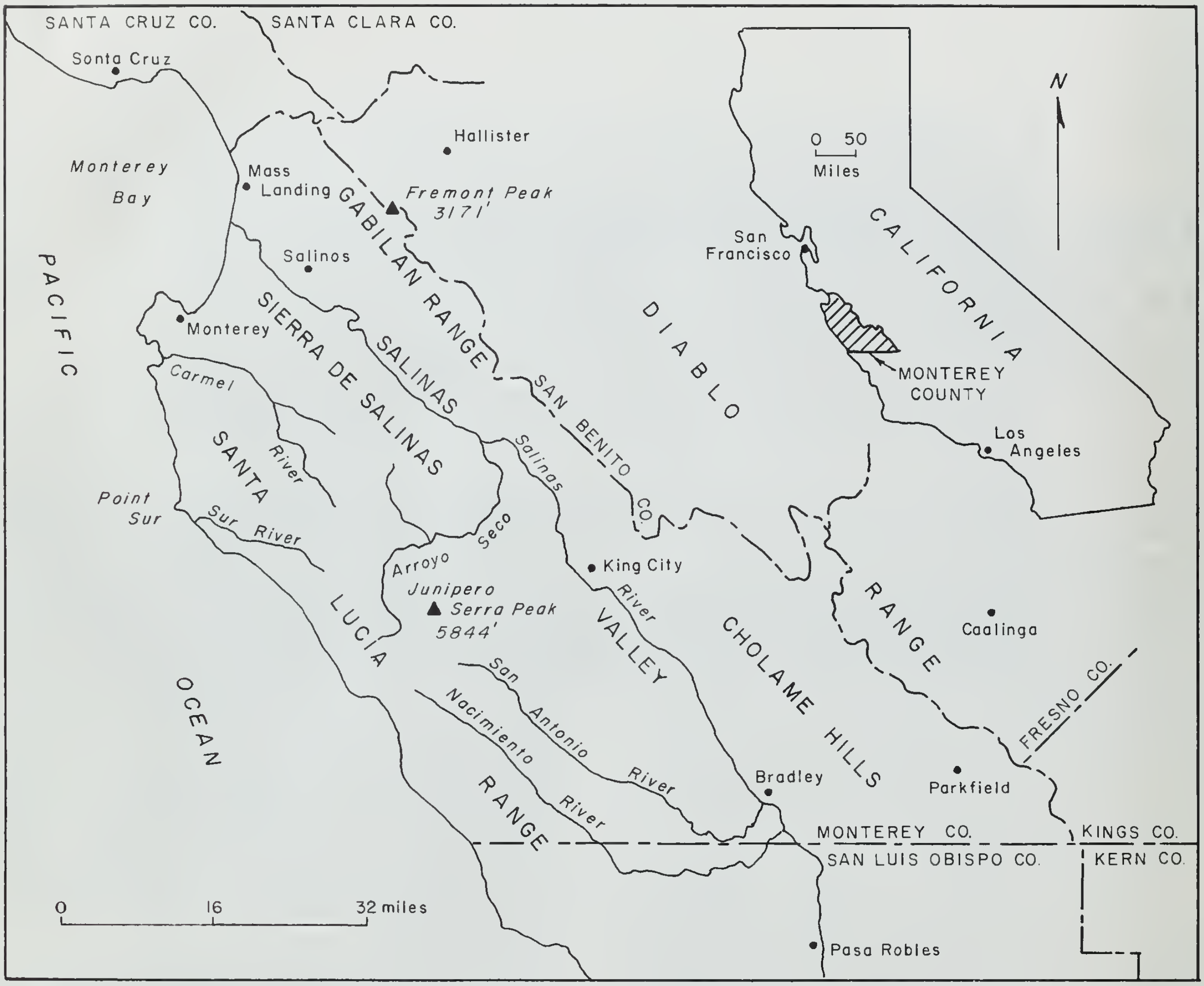

Figure 1. Index map showing the principal geographic features of Monterey County.

included portions of San Benito and San Luis Obispo Counties (Coy, 1919, p. 309). The county lies entirely within the Coast Ranges and presently occupies 3,324 square miles of area. It has a maximum length of 99 miles in a northwest direction and an average width of about 40 miles.

The main physiographic features include the rugged Santa Lucia Range and Sierra de Salinas in the southwest and the Gabilan Range, Cholame Hills, and part of the Diablo Range in the northeast; the two areas being separated by the broad, northwest-trending Salinas Valley. Junipero Serra Peak, in the Santa Lucia Range, at an elevation of 5,844 feet, is the highest point in the county. Most of the county is drained by the Salinas River and its many tributaries. A smaller drainage area, which includes the northwest Santa Lucia Range and southwest Sierra de Salinas area, is drained by the Carmel River. The coastal part of the Santa Lucia Range is drained directly into the ocean by the Sur River and numerous smaller streams. Also of considerable interest is the adjacent ocean floor which consists of a very narrow shelf and a steep continental slope that is deeply incised by several submarine canyons. One of these canyons, Monterey Canyon, can be traced 90 miles southwest (to a depth of 12,000 feet) from a point a few hundred feet from the beach at Moss Landing (Shepard and Emery, 1941). The topography of the rugged slope area is believed to have been sculptured primarily by submarine erosion.

Rainfall varies considerably from one part of the county to another and from year to year. An average of 13½ inches of rain falls per year at Salinas, which is similar to other parts of the Salinas Valley. However, precipitation is less in the valleys to the east (e.g. Cholame Valley) and much greater in the coastal mountains to the west.

The population has risen rapidly in recent years from 27,980 in 1920 to 198,824 in 1960. Half of the

Photo 1. Panorama across Salinas Valley toward northern Sierra de Salinas; observer facing southwest from Fremont Peak. City of Salinas is in middle ground. *Reprinted from Bowen and Gray 1959, photo 4.*

people live in 11 incoporated cities and towns and almost all live in the Salinas Valley, Monterey Bay, Monterey Peninsula, and Carmel Valley areas. The largest city is Salinas, the county seat, with a population of 28,957 in 1960. This is followed by Monterey (22,618), Seaside (19,353) and Pacific Grove (12,121). King City is the largest town in the southern half of the county with 2,937 people. Agriculture is the most

Photo 2. View southeast toward Swamp Creek area from Fremont Peak. This gently rolling surface is a remnant of a late Tertiary erosion surface and now lies along the crest of the northern Gabilan Range. *Reprinted from Bowen and Gray 1959, photo 5.*

Photo 3. View to north of rugged coastline surmounted by Sonto Lucio Range at Big Creek. The foceted cliffs ond deeply incised conyon exemplify the youthful stage of erosion. Peoks in bockground rise to elevotion of 4,000 feet. *Photo courtesy of Notionol Park Service (May 1957).*

important industry, being valued at more than $100,000,000 per year. Mining is another important industry and mineral production has exceeded $23,695,000 yearly since 1955. The manufacturing industry is closely associated with the production, processing and shipping of agricultural and mineral products. Resort and recreational facilities and areas, particularly along the coast, also are responsible for a large source of income. The significance of the fishing industry has decreased considerably in the last decade or so due mainly to a sharp decline in the sardine catch.

Transportation facilities are excellent in the populated areas, but generally poor in the southeast part of Monterey County and in the rugged Santa Lucia Range. The main line of the Southern Pacific railroad connects the Salinas Valley with Los Angeles and San Francisco and a spur line extends from Pacific Grove to Castroville. U. S. Highway 101 and State Highway 1 are the major arterials to the north and south. Some of the connecting roads, especially in the Santa Lucia Range, are not surfaced and generally are impassable during wet weather. Ocean shipping facilities are available at Monterey and Moss Landing. About a dozen county, municipal, and private airports exist throughout the county.

The land classification of Monterey County could not be ascertained in detail, although 32% is Federally owned. As only a small percentage of land is owned by the state, county and cities, it is concluded that well over half of the land is privately owned. Much of the private land is held in the form of large ranches, many of which were obtained originally as Mexican land grants. Of the land under Federal ownership, 15%, 13% and 4% of the county is under the control of the Departments of Agriculture, Defense, and Interior, respectively (Dana and Krueger, 1958, p. 85). Land open to mineral location (Public Domain) in Monterey County is controlled mainly by the Department of Agriculture (U.S. Forest Service), although some may be under the jurisdiction of the Department of Interior. In other words, prospecting and subsequent mineral location is limited to the Los Padres National Forest in the Santa Lucia Range, and possibly some smaller areas in the southeastern part of the county. In addition, a small part of the Los Padres National Forest is limited to mineral leasing under the Weeks Act of 1911. Further information regarding land open to mineral location or leasing can be obtained from: (1) District Forester, U.S. Forest Service, King City; (2) U.S. Bureau of Land Management, Sacramento and Riverside. Exploration and development of land owned by the State of California (tide and offshore lands, navigable rivers, etc.) is under the jurisdiction of the State Lands Commission, which issues prospecting permits and leases at its offices in Los Angeles and Sacramento. For mineral prospecting and leasing of private lands, permission should be obtained from the owner of the land. Information on ownership can be obtained from the Monterey County Assessor in Salinas.

Photo. 4. Bell tower of Carmel Mission (San Carlos Barroméa). Tower is part of the seventh and last church constructed (1793-1797) at Carmel Mission and depicts the early use of Carmel Valley type stone, mortar (adobe soil and lime) and tile. *Photo by Rey Ruppel, courtesy Monterey Peninsula Chamber of Commerce.*

Because much of the readily accessible land has existed as large, privately-owned ranches and much of the rest of the land is of difficult access, mineral prospecting has not been particularly thorough, except for gold and possibly mercury. Individual prospectors were mainly interested in finding metallic mineral deposits, with which the county is not overly endowed, and exploration and development of the more important industrial minerals has been discouraged to some extent by land owners primarily interested in agriculture or by residents concerned with the conservation of the natural beauty of Monterey County. As a consequence, several non-metallic mineral deposits (e.g. sand, gravel, limestone, diatomite) of considerable future value remain to be developed. Smaller metallic deposits, such as chromite, mercury, and manganese, also may be discovered and developed commercially.

HISTORY OF MINING AND MINERAL UTILIZATION

Pre–1850. The earliest records of mineral development and utilization are revealed at the Presidio of Monterey and the Franciscan Missions at Carmel, San Antonio, and Soledad. These structures were built of adobe, stone, brick tile and lime-mortar and were decorated with paints made from lime, cinnabar and ochre as coloring pigments. The Presidio and Carmel Mission (Mission San Carlos Borromeo) were founded in 1770 and the first construction was of wood, straw and adobe soil. Lime was used very early as whitewash in the interior of some of the buildings. Adobe brick was manufactured as early as 1774, when it was utilized in the construction of a large kitchen stove at the Presidio of Monterey (Watkins, 1925, p. 94). The use of adobe and stone in the construction of walls and the manufacture of brick tile for roofing may have been common prior to 1792. In that year, reconstruction of the church at the Presidio was commenced using stone (Egenhoff, 1952, p. 33 and Guinn, 1902, p. 57, 69).

The most complete and varied early use of mineral commodities was in 1793–1797, when the seventh and last church at Carmel Mission was constructed. According to Harry Downey (1959, personal communication), a restorer of the Carmel and other missions for the last 20 years, the Indians, under the direction of the Mission Fathers, began quarrying diatomaceous and siliceous shale and sandstone of the Monterey Formation as early as 1790 for use in the last mission church. Traces of this quarry still can be seen on the steep north slope of the hills just south of the Carmel River, and one mile east of State Highway 1. This stone, which is similar to the stone quarried commercially in Carmel Valley in recent years, was used structurally in the walls, stairs, tower and foundations of the church. (J. D. Whitney reported in 1865, on pages 153–154, that Miocene sandstone from quarries 2 miles southeast of Monterey was used to build Carmel Mission). In addition, field stones of Santa Lucia granodiorite and Paleocene conglomerate were gathered from local sources, including the Point Lobos area, for use in the foundations. Adobe soil and lime were utilized for mortar, the soil being obtained from

Photo 5. Partly restored gristmill built in 1806 at Mission San Antonio de Padua. Constructed of stone, brick, and clay, the mill was powered by water directed against the wheel through a clay pipe (lower chamber). Grinding was done between millstones housed in upper chamber. *Photo courtesy Salinas Chamber of Commerce.*

the floodplain of the Carmel River. Sea shells, especially from the Indian kitchen middens, were the most convenient source of lime. However, Mr. Downey believes that lime also was obtained from caliche subsoils and, later, from crystalline limestone near Bixby Creek 15 miles to the south. Aside from being mixed with adobe to form mortar, lime was used as whitewash for both interior and exterior walls. Adobe soil also was used to make adobe brick, which was employed to a considerable extent in and around the mission. Brick tile used to roof the church and cap some of the walls was fired in a large kiln constructed under the direction of the Mission Fathers. Local sources of clay and sand from the Carmel River provided the raw material for the tile. The cinnabar used for painting and decorating is reported to have come from the New Idria area in San Benito County and the ochre from near Jolon (Downey, personal communication).

Missions San Antonio and Soledad, established in 1771 and 1791, respectively, were constructed mainly of adobe brick and mortar made from local soil materials. San Antonio was the more elaborate and larger, employing clay tiles for roofing and wall cappings (Egenhoff, 1952, p. 157, 160, 169). Stone was used to make a mill for grinding wheat and a stone-lined ditch caried water to operate the mill (Hoover, 1937, p. 223). Limestone near each of the missions was undoubtedly used to make lime for mortar and whitewash.

Adobe and stone construction methods introduced by the Mission Fathers were adopted by the settlers in the early 1800's, although the Indians continued to build their huts of wood and straw. Many of the larger ranches established brick yards for the construction of many handsome adobe structures, but few of these buildings stand today. However, the Custom House in Monterey, built 1814–1822, has been restored and stands as a fine example of adobe and stone construction. Colton Hall in Monterey, built 1847–1849 and also in good condition, remains as a splendid instance of stone construction. The stone is siliceous shale of the Monterey Formation, obtained from a nearby hill.

From the above history, it is probable that the manufacture of adobe brick, tile, and lime and the quarrying of stone were the only significant mineral industries prior to 1850. The few other mineral materials needed were most likely imported into the county.

Post–1850. The year 1850 marked the beginning of California as a state and Monterey as a county. The "Mission-Rancho" way of life also was giving way to a period of individual achievement. Part of this achievement was made in the mineral industry and first centered on the prospecting and mining of gold. J. B. Trask (1854, p. 58) reported that placer gold was known to exist around the Jolon area since 1850 and miners were working the placers shortly thereafter. Gold prospecting and mining also were conducted about 1853 along the middle and upper reaches of the Carmel River and its tributaries and elsewhere in the Santa Lucia Range. Possibly even earlier than 1850, silver-bearing galena was reportedly mined east of Salinas (Trask, 1854, p. 55–56; Bancroft, 1886, p. 144, 176). Trask also reported (1854, p. 21) that granite was quarried at Point Pinos to construct the lighthouse there.

In addition to the above mining activities, J. D. Whitney reported in 1865 (p. 158–162) that a large amount of granite was quarried at Point Lobos and that large quantities of white sand suitable for glass manufacture existed at Cypress Point and Pescadero Beach. The first reported use of dune sand from Monterey County began at least as early as 1867 when it was mined for use by the San Francisco glass industry to make lighthouse glass and wine bottles. J. R. Browne (1868, p. 251) reported that two of the glass works employed 150 men and boys and annually produced $250,000 worth of glassware, using the deposits "near the harbor of Monterey" as their chief source of sand.

During the early 1870's, important deposits of coal and mercury were discovered and some of each were produced. A commercial lime-burning operation at Limekiln Creek (near Lucia) was established in the 1880's, followed in 1887 by the discovery of the Buclimo (Last Chance) gold mine in the Los Burros district. That last event touched off the biggest prospecting surge ever seen in Monterey County, but resulted in only modest production of gold.

At the turn of the century, a wider variety of construction materials came into commercial use, including crushed stone, bituminous sandstone, sand and gravel, and brick. About 9 other mineral industries were established since then, the most important being those of diatomite (1906), salt (1916), dolomite (1917), magnesium compounds (1942), and oil and gas (1947).

Geology

Monterey County lies totally within the Coast Ranges physiographic province of California where the geology is typically diverse and complex. Because of complicated structural and stratigraphic relationships, the geologic history of the region is only partly understood. Although rocks of the county date back to the Late Jurassic(?) or earlier, not much is known prior to the Late Cretaceous when the Sur Series metamorphic rocks were intruded by granitic rocks during one of the major mountain building epochs. Since then, portions of the area have been inundated many times by ancient seas in which primarily clastic sediments were deposited. Marine deposition was interrupted periodically by uplift associated with severe erosion. Prior to the Miocene Epoch, either the seas were quite restricted or erosion was great, as the Miocene and Pliocene formations commonly lie directly

on the older "basement" rocks. In late Pliocene time, renewed uplift marked the last withdrawal of the ancient seas. This orogenic disturbance lasted until mid-Pleistocene time and was the most severe orogeny recorded in the southern Coast Ranges. The formations were strongly deformed by folding and dislocated by normal, lateral and thrust faulting during this episode. By mid-Pleistocene all of the major topographic features and drainage patterns that now exist were formed. Crustal disturbances since then have been relatively minor, and appear to be confined mainly to lateral movement along the San Andreas fault zone and some warping and tilting over a large part of the region. More detailed and perhaps somewhat different accounts of the geologic history of the central and southern Coast Ranges can be seen in Reed (1933), Taliaferro (1943, p. 119–163), Hinds (1952, p. 157–181), Oakeshott (1960, p. 1–13), American Association of Petroleum Geologists, et al. (1963), and many other references.

ROCK UNITS AND ASSOCIATED MINERAL DEPOSITS

The geologic formations of Monterey County have formed under a wide variety of sedimentary, igneous and metamorphic conditions. Related types and sequences of rocks have been classified as formations or other mappable units (e.g., group, series, member) by geologists who have mapped parts of the region. In order to show them on the geologic map (Plate I), some of the formations have been combined into larger units. The chief rock types and distribution of the formations are described below according to age, beginning with the oldest. Relationship of the formations to the units shown on the map are indicated parenthetically by map symbols.

Mineral deposits related to the various formations are indicated in the following paragraphs and this information is summarized in Table 1. More detailed data concerning the relationship between geology and mineral deposits is given in the section on Mines and Mineral Resources. The importance of associating the mineral deposits with geology cannot be over emphasized, as geology can be of great benefit in efficiently locating and developing new deposits.

Sur Series (m, ls) and granitic rocks (gr). Metamorphic rocks of the Sur Series (m) probably are the oldest rocks in Monterey County. These rocks include schists, gneisses, crystalline limestone and dolomite, quartzite, and a variety of contact metamorphic rocks. Sur Series rocks were derived from sand, mud, limy sediments and some volcanic rocks deposited in a marine environment. Wide-spread exposures in the Santa Lucia and Gabilan Ranges and along the San Andreas fault zone testify to the extensive seas existent at the time of deposition of these sediments. The age of the Sur Series is not known, but it can be no younger than the Upper Cretaceous granitic rocks that intrude the series. Some geologists believe the Sur Series is much older than the intrusive rocks and may have been deposited during the Paleozoic Era. The Sur Series of the Santa Lucia Range has been described in detail by Trask (1926) and Reiche (1937), who estimate the thickness to be between 5,000 and 10,000 feet. Bowen and Gray (1959, p. 11) have divided the Sur Series of the northern Gabilan Range into 3 units which have a total thickness of more than 8,300 feet. Neither a top nor a bottom has been recognized for the sequence.

Intruding the Sur Series are large bodies of granitic rock known as Santa Lucia Quartz Diorite (gr). These rocks range in composition from quartz diorite to granodiorite and granite and include various porphyritic and pegmatitic facies. Like the metamorphic rocks, the granitic rocks are widely exposed in the Gabilan and Santa Lucia Ranges and also are found along the San Andreas fault zone in the southeast part of the county. Since several samples of the granitic rock were analysed by potassium-argon age-dating methods (Curtis, et al., 1958, p. 9, 13; Hay, 1963, p. 113), most geologists consider at least part of the Santa Lucia Quartz Diorite to be early Late Cretaceous in age. Exposures and drill data indicate the Sur Series and Santa Lucia Quartz Diorite underlie, at depth, the entire region defined by the San Andreas and Nacimiento-Sur fault zones, but do not extend beyond that area. This crystalline complex is overlain unconformably by Upper Cretaceous and Cenozoic sedimentary rocks.

The Sur Series and associated granitic rocks are of considerable economic importance. Crystalline limestone and dolomite ("Gabilan limestone") of the Sur Series are important sources of lime, magnesium refractories, roofing granules, and other materials, and may prove to be important sources of cement. In addition, barite occurs in the crystalline limestone at Fremont (Gabilan) Peak where it once was produced commercially. Contact metamorphic zones commonly are developed where limestone has been intruded by

Photo 6. Fremont Peak observed from the east. The twin peaks consist of silicified dolomitic limestone separated (saddle area) by a tongue of schist; both rock types are of the Sur Series. *Reprinted from Bowen and Gray 1959, photo 1.*

Table 1. Summary of economic geology of Monterey County.

Geologic age			1/ Map symbol	Formation and rock types	Mineral deposits 2/ (CAPITAL LETTERS indicate past production)
		Recent	Qs	Dune and beach sand	SPECIALTY and CONSTRUCTION SAND, FELDSPAR, SILICA
			Qso	Older dune sand	
	QUATERNARY		Qal	Alluvial sand, gravel, clay	SAND, GRAVEL, COMMON CLAY, peat
			Qt	Stream terrace and fan deposits - sand, gravel, clay	Minor SAND, GRAVEL, ADOBE CLAY
			Qm	Marine terrace deposits	
		Pleistocene	Qc	Aromas Red Sands	Sand (?)
			QP	Paso Robles - sand, gravel, clay	
			Pc	Undivided nonmarine sedimentary rocks	
		Pliocene	Pml	Etchegoin, Etchegoin-Jacalitos, Pancho Rico – mainly marine shale, sandstone, conglomerate, diatomaceous shale	BITUMINOUS SANDSTONE, coal
			Mc	Undivided nonmarine sandstone and conglomerate	3/
CENOZOIC			Mu	Santa Margarita, San Pablo, Mc Lure Shale – brown and white sandstone, shale, conglomerate, diatomaceous shale	OIL, GAS, bituminous sandstone, specialty sand
			Mm	Monterey, Salinas Shale – marine, siliceous and diatomaceous, shale, diatomite, sandstone	OIL, GAS, DIATOMITE, BUILDING STONE, phosphates
		Miocene	Mmc	"Temblor" – largely nonmarine sandstone, conglomerate, shale	COAL (minor)
	TERTIARY		Ml	Sandholdt, Temblor, "Vaqueros-Temblor", Vaqueros – mostly marine sandstone, siltstone, shale, conglomerate with some nonmarine rocks and volcanic flows	COAL, specialty sand (?) 3/
			Mv	Pinnacles and unnamed volcanic rocks – vent tuff and breccia, rhyolite and andesite flows and dikes	Uranium 3/
			Φc	Berry Conglomerate – nonmarine sandstone, conglomerate	
		Oligocene	Φ	San Lorenzo Group, "Church Creek beds" (upper part only) – mudstone, siltstone, sandstone, conglomerate	3/
		Eocene	E	The Rocks Sandstone, Point of Rocks Sandstone, Lucia Shale, Canoas Siltstone, Junipero Sandstone, Avenol Sandstone	3/
		Paleocene	Ep	Carmelo Series, Martinez, and unnamed units – marine mudstone, siltstone, sandstone, conglomerate	
			K	Undivided marine sedimentary rocks	
			Ku	Asuncion Group, Panoche, Moreno Shale – marine sandstone, conglomerate, shale, siltstone	MERCURY (minor) 3/
	CRETACEOUS		Kl	Marmolejo, Badger Shale, Shasta Group, undivided – marine clay shale, sandy shale, sandstone	
			gr	Santa Lucia granodiorite, quartz monzonite, quartz diorite – mainly granitic and porphyritic rocks with some pegmatite and gneiss	FELDSPAR, DECOMPOSED GRANITE, RIPRAP, BUILDING STONE (rubble)
MESOZOIC			Jk	Knoxville – mainly marine shale with some sandstone and other Franciscan-like rocks	
			KJf	Franciscan Formation – marine sandstone, shale, chert, conglomerate, with small areas of serpentine, greenstone, schist	GOLD, SILVER, CRUSHED and BROKEN STONE, MERCURY, manganese
	JURASSIC		KJfv	Franciscan volcanic rocks – greenstone, basalt, diabase	3/
			ub	Ultrabasic intrusive rocks – serpentine, peridotite	MERCURY, CHROMITE, JADE, asbestos, magnesite
PALEOZOIC ?	UNDIVIDED		m ls	Sur Series undifferentiated (m) and Sur Series limestone (ls) – schist, gneiss, crystalline limestone and dolomite, various contact metamorphic rocks; includes minor amounts of granitic rocks	LIMESTONE, DOLOMITE, BARITE, copper, tungsten, molybdenum 3/

1/ Symbols represent units shown on Geologic Map (Plate I).
2/ Does not include low-grade sand, gravel, and crushed stone deposits used solely as sources of fill and subbase material.
3/ Potential sources of crushed and broken stone occur locally in well-indurated sandstone and volcanic rocks.

Photo 7. View southeast across Carmel Bay showing jointed granodiorite at Midway Point (foreground) and northern Santa Lucia Range in distance. The higher mountains are underlain by granitic rocks, which in turn are overlain by Tertiary sedimentary rocks in the lower hills to the north (left background). *Rey Ruppel photo, courtesy Monterey Peninsula Chamber of Commerce.*

igneous rocks. Tungsten, copper and molybdenum minerals have been noted in such zones, but commercial deposits have not been developed thus far. The larger masses of "Gabilan limestone" (ls) are outlined on the geologic map (Plate I). "Decomposed granite" used as fill and base materials in road construction has been the main commodity obtained from the granitic rocks. Less weathered granitic rock has been utilized as crushed and broken stone and as building stone (rubble). However, most of the granitic rocks exposed are rather deeply weathered. Potash feldspar obtained from granite pegmatite near Chualar also was produced commercially.

Franciscan Formation (KJf, KJfv) and associated rocks (Jk,ub). The Franciscan Formation and its associated intrusive rocks are the oldest exposed rocks west of the Nacimiento-Sur fault zone and east of the San Andreas fault zone. The age of these rocks is not accurately known because fossil evidence is scarce and stratigraphic relationships of the Franciscan Formation to overlying and underlying formations are inadequately known. Similar rocks elsewhere in California are considered to range in age from Late Jurassic(?) to early Late Cretaceous, primarily on the basis of scant fossil data. Typical rocks of the Franciscan are dark gray sandstone (graywacke), black shale, thinly-interbedded red chert and shale, and basic volcanic flows and agglomerates partly altered to greenstone. The thicker sequences of volcanic rocks (KJfv) have been differentiated on the geologic map. The formation is intruded by dikes and sills of basic igneous rocks and larger bodies of ultrabasic rocks (ub), the latter being mostly altered to serpentine. Associated with the Franciscan Formation are small masses of glaucophane and actinolite schists and other metamorphic rocks. Franciscan rocks are strongly sheared and folded and, in general, weakly metamorphosed. Maximum thickness of the formation is not known, but exceeds 10,000 feet. Sediments and volcanic rocks of the Franciscan Formation were deposited under marine conditions in a great and rapidly-sinking trough. Just why no Franciscan rocks have been found between the San Andreas and Nacimiento-Sur fault zones is not determined. It may be that the Franciscan rocks were formed in two separate basins of deposition. Another possibility is that they formed in a common basin that was subsequently broken by faulting and dislocated by large crustal movements. This remains one of the great unsolved geologic problems of California.

Overlying the Franciscan rocks at one place in the southwest part of the county is a small remnant of the Knoxville Formation (Jk) which typically consists of thick sequences of dark shale with subordinate amounts of Franciscan-like rocks. The age of the Knoxville Formation is generally considered to be Late Jurassic.

Several of the many mineral commodities found with the Franciscan and associated rocks have been produced commercially in Monterey County. Sheared and slaty sandstone and shale of the Los Burros district have acted as a host for quartz veins which carry gold

and minor amounts of associated silver and copper. Less important to date, but of future potential is crushed stone derived from sandstone and other tough Franciscan rocks. Also, subcommercial amounts of manganese oxide are found in several places in thinly-bedded chert. Mercury minerals occur commercially in serpentine and silica-carbonate rocks, particularly in the southeast part of the county. Chromite also has been produced from serpentine in several areas. Other minerals associated with serpentine are asbestos and magnesite, neither of which have been found in economic amounts. Perhaps more glamorous is the gemstone, nephrite jade, developed in sheared and metamorphosed serpentine and Franciscan sedimentary rocks at Cape San Martin. Olivine, constituting most of the periodotite core of the Burro Mountain ultrabasic mass, also may be of future economic interest.

Cretaceous rocks (K, Kl, Ku). The Cretaceous Period is subdivided into Early Cretaceous and Late Cretaceous Epochs and both epochs are represented in the rocks of Monterey County. Lower Cretaceous strata (Kl) consist of dark clay-shales and sandy shales intercalated with thin sandstone beds, which are exposed in a few places east of the San Andreas fault, and as a single patch near the southwest corner of the county. These rocks have been referred to as the Marmolejo Formation by N. L. Taliaferro (1944, p. 458–469), as the Badger Shale by O. T. Marsh (1960, p. 9–12), and as the Shasta Group or undifferentiated Cretaceous by most other workers. These rocks lie unconformably on the Fanciscan Formation or Knoxville Formation. As far as known, the Lower Cretaceous strata contain no economic mineral deposits.

Upper Cretaceous formations (Ku) are much more commonly exposed than the Lower Cretaceous rocks, being found in the Santa Lucia Range, and east of the San Andreas fault zone. In the Santa Lucia Range, Taliaferro (1944), has divided the Upper Cretaceous strata into two units the lower of which has not been identified in Monterey County but is exposed to the south in San Luis Obispo County. The younger Asuncion Group was deposited in seas covering much of the range, as indicated by the wide distribution of outcrops. Unlike the older Cretaceous formations, the Asuncion is typified by coarse sandstone and conglomerate with subordinate shale. The maximum thickness of the Asuncion is believed to be in excess of 6,000 feet. East of the San Andreas fault, Upper Cretaceous sandstone, shale, siltstone and conglomerate are exposed in thick sequences that have not been adequately mapped or defined in the literature. Generally the rocks are referred to the Panoche Formation (or Group) and overlying Moreno Formation, but locally the strata have been defined in more detail and different formation names applied.

The only mineralization known in the Upper Cretaceous rocks is at the Botts mine where mercury ore was deposited along a fault zone in sandstone. Undeveloped but of economic potential are some of the hard sandstone beds, as a source of stone, and certain shale and bentonite beds as sources of clay materials.

Paleocene rocks (Ep) Marine formations of Paleocene age are exposed discontinuously from Carmel Bay southeast to the headwaters of the San Antonio River in the Santa Lucia Range. These rocks have been referred to as the Carmelo Series (Lawson, 1893) and Martinez Formation (Reiche, 1937), but mostly are unnamed. In the Junipero Serra quadrangle, they typically consist of dark mudstone, siltstone and various sandstone beds which aggregate 5,000 feet in total

Photo. 8. Point Sur, composed of Franciscan volcanic rocks and a gabbro intrusive, is a resistant erosional remnant surmounted by a lighthouse facility along the Monterey coast. Marine terrace deposit of the mainland (foreground) is separated from the point by Recent beach and dune sands. *Photo by Mary Hill.*

Photo. 9. Northeosterly dipping Eocene stroto resting on old Sur Series and gronitic rocks of the bosement complex. The Eocene rocks consist of Lucia mudstone conformobly overloin by resistont beds of The Rocks Sondstone. *Photo by Mory Hill.*

thickness (Compton, 1957, p. 1820). At Carmel Bay, the Paleocene strata are mainly sandstone with interbedded conglomerate. Some of the sandstone south of Jolon (shown as Upper Cretaceous rocks on Plate I) also may be of Paleocene age (Durham, 1965, p. 7 and Pl. 1). Economic deposits have not been developed in the Paleocene rocks.

Eocene rocks (E). Formations laid down during Eocene time are distributed a little more widely than strata of Paleocene age, being exposed in the north-central Santa Lucia Range and the southeast corner of the county. In the Santa Lucia Range, the rocks consist of massive arkosic sandstone of early to middle Eocene age (Junipero Sandstone), thinly-bedded silty mudstone of middle Eocene age (Lucia Shale), and thickly-bedded massive sandstone of late Eocene age (The Rocks Sandstone). In places these marine strata have a total thickness of 1,500–2,000 feet. Eocene strata in the southeast corner of the county and adjacent Kings County are of comparable age, but have a somewhat different nomenclature. They consist of middle Eocene massive sandstone (Avenal Sandstone) and upper Eocene siltstone (Canoas Siltstone) and massive sandstone (Point of Rocks Sandstone) totalling over 2,000 feet thick. The Eocene formations contain no known commercial mineral deposits, although the well-indurated, massive sandstones could be used for crushed or broken stone.

Oligocene rocks (Φ, Φc). The Oligocene Epoch is represented by rocks of both continental (Φc) and marine (Φ) origin in the north-central Santa Lucia Range and by marine beds at the northern end of the Gabilan Range. Nonmarine Oligocene rocks in the Santa Lucia Range are termed the Berry Formation or Berry Conglomerate, which typically consists of massive conglomerate and sandstone beds aggregating as much as 1,500 feet thick. To the northwest in Church Creek, a thin-bedded mudstone, siltstone and sandstone unit 1,500 feet thick occurs as a marine equivalent to the Berry Formation. The Oligocene rocks exposed in the northern Gabilan Range consist of massive marine sandstones of the San Lorenzo Group that attains a thickness of about 2,500 feet. Sandstone of the upper 1,000 feet (Pinecate Formation) is well cemented, standing in rugged cliffs, and could be useful as a source of crushed and broken stone.

Miocene rocks (Ml, Mm, Mmc, Mu, Mc, Mv). Miocene sedimentary rocks are particularly widespread in Monterey County, and thick sections are exposed almost continuously from the Monterey Peninsula southeastward along the eastern flank of the Santa Lucia Range to the south county boundary. Miocene rocks also are exposed near Point Sur, in the northern Gabilan Range and Cholame Hills, and east of the San Andreas fault zone. Because of the crustal disturbances, climatic changes, and some igneous activity during the Miocene, a wide variety of sedimentary and volcanic rocks were formed. Consequently, a number of formational names have been applied, both regionally and locally, to various rock sequences of that epoch. The most important formations include the Vaqueros (lower Miocene); Temblor or Sandholdt (lower and middle Miocene); Monterey (middle and upper Miocene); and Santa Margarita, San Pablo or McLure Shale (upper Miocene).

The Vaqueros Formation (Ml), including undivided Vaqueros-Temblor rocks, comprises the oldest Miocene rocks. Generally, it consists of massive, arkosic sandstone with small amounts of interbedded siltstone and conglomerate which comprise a total thickness as much as 2,000 feet. Locally, the Vaqueros is interbedded with or overlain by andesite or basalt flows. Although most of the Vaqueros is of marine origin, some of the beds may have formed under continental conditions. The formation is exposed widely in the Santa Lucia Range and at the northern tip of the Gabilan Range.

Conformably overlying the Vaqueros Formation west of King City is the lower to middle Miocene Sandholdt Formation (Ml), which consists of clay shale with some interbedded sandstone, siltstone, limestone and conglomerate. These marine strata are about 1,000 feet thick.

Elsewhere in Monterey County, lower to middle Miocene sedimentary rocks usually are mapped as the Temblor Formation. In the southeast part of the county, the Temblor Formation (Ml) consists mainly of massive, arkosic, marine sandstones that aggregate about 2,000 feet in thickness. In the northern part of the Santa Lucia Range the Temblor (Mmc) is predominantly continental, consisting of a wide variety of rock types, including marine and nonmarine sandstone, shale, conglomerate, andesite flow-rocks, siltstone and a little coal.

One of the most extensively exposed sequences is the Monterey Formation (Mm) of middle and late Miocene age. Where complete sections are preserved, it frequently can be subdivided into 3 members: a basal sandstone, a middle siliceous shale, and an upper diatomite. The basal sandstone is often thin or missing, but in the subsurface southwest of King City it develops a thickness of more than 1,000 feet. Thinly-bedded siliceous shale typical of the middle unit generally is folded and faulted, but apparently attains a maximum thickness of 6,000 feet or more. Gradationally overlying the siliceous shale, the upper member contains poorly-bedded white to buff diatomite and diatomaceous siltstone that attain a total thickness of at least 500 feet. The Monterey Formation crops out almost continuously in the Santa Lucia Range from Monterey to San Luis Obispo County. Southeast of King City it laps eastward onto the southern part of the Gabilan Range where the Monterey Formation thins and probably, in part, grades laterally into the lower portion of the Santa Margarita Formation.

The Santa Margarita Formation (Mu) is exposed in many places in the Santa Lucia Range as a relatively thin unit that generally rests on the Monterey Formation. This upper Miocene formation also has been called the San Pablo Formation in the northern part of that region. Massive brown and white sandstones that are sometimes unconsolidated characterize these formations, although other sedimentary rock

Photo 10. View to north of region between Cormel River ond Chupines Creek, o northeost tributory. Hills in middle ground ore developed in Monterey Formotion ond rocks of the Voqueros-Temblor from the ridge in the bockground. Older Sonto Lucio gronitic rocks crop out on ridge (for upper left) ond conyon (upper right). *Photo by Mory Hill.*

types are often present. East of the Salinas River, in the Cholame Hills, the Santa Margarita Formation is at least 2,500 feet thick. Here, a lower unit of sandstone and conglomerate grades upward into an upper siliceous shale unit, the latter grading laterally into coarse sandstone. Taliaferro (1943, p. 460) considers the upper unit to be equivalent to the McLure Shale which, along with the Reef Ridge Shale, comprises the upper Miocene rocks lying east of the San Andreas fault.

In addition to the above formations, unnamed Miocene rocks (Mc) of continental origin are found in the Cholame Hills and along the Nacimiento River. In the latter area, massive, coarse sandstone and conglomerate beds stand as strikingly resistant outcrops locally named The Palisades and The Shut-in.

Rhyolite tuffs, breccias, flows and dikes of the Miocene Pinnacles Formation (Mv) form the interesting craggy exposures at Pinnacles National Monument in the Gabilan Range. Rhyolitic flow rocks on the west side of Cholame Valley may be related to the Pinnacles Formation.

Economically, the Miocene rocks have been the most valuable source of minerals produced in Monterey County. Petroleum and natural gas are the most important of these, having been produced in vast amounts from upper Miocene sands at the San Ardo field. Additional oil and gas have been obtained from upper and middle Miocene sands of the Monterey Formation in several small fields near King City. The Monterey Formation also contains large quantities of diatomite in its upper member and this has been developed commercially in the Hames Valley area near Bradley and at the Work Ranch east of Monterey. Siliceous shale for building stone also has been obtained commercially, almost solely from the Carmel Valley area. The Temblor Formation has been the principal source of coal which was produced from the Stone Canyon and Carmel coal mines. In fact, the highest-rank coal in California occurs at the Stone Canyon deposit. Only minor amounts of other mineral commodities were produced from Miocene formations. One of these commodities is white sand from the Santa Margarita Formation which is believed to be a large, potential source of specialty and construction sands. Other white, poorly-consolidated sands of the San Pablo and Temblor Formations also may have economic potentials. Pelletal phosphorite beds associated with Monterey shale may be of future economic interest.

Pliocene rocks (Pml, Pc). Because Pliocene strata were formed so late in geologic time, they are widely exposed in southern and eastern Monterey County. For the most part, the formations consist of marine shale, sandstone, siltstone, conglomerate, and various diatomaceous rocks. Most of these are soft, and erosion results in subdued outcrops. Several formational names have been applied to the Pliocene units, but not always in a consistent manner. Generally speaking, east of the San Andreas fault the names Jacalitos and Etchegoin or Etchegoin-Jacalitos are applied to lower and middle Pliocene beds (Pml). In the Cholame Hills-southern Gabilan Range area, the term Pancho Rico (also known as Poncho Rico) is generally used for equivalent strata. All of the above names have been employed west of the Salinas River. Some nonmarine Pliocene beds (Pc) crop out sporadically east of the San Andreas fault and north of Point Sur. The Pliocene strata reach a maximum development of several thousand feet in the Priest Valley area east of the San Andreas fault, but average about 1,000 feet thick in the Cholame Hills and usually are even thinner west of the Salinas Valley.

Commercial mineral development is minor in the Pliocene beds and only small amounts of bituminous sandstone have been mined near Lonoak and Bradley. Thin seams of Pliocene coal in Priest Valley and phosphorite near San Lucas also have been prospected.

Plio-Pleistocene rocks (QP). These rocks are represented by the Paso Robles Formation which is widely distributed on both sides of Salinas Valley, particularly in the southern half of the county. The formation consists of conglomerate, sandstone, silt, clay and some limestone deposited chiefly as fan and basin deposits under fluviatile and lacustral influences. Debris from siliceous Monterey shale typify the conglomerates, although granitic and Sur Series debris locally may comprise 100% of the formation, as at San Benancio Gulch at the northern end of the Sierra de Salinas. Paso Robles sequences attain a maximum thickness of about 2,000 feet. The formation ranges in age from late Pliocene to about mid-Pleistocene.

The only commercial materials thus far produced from the Paso Robles Formation are sands and gravels that have been used for fill and base materials in road construction. The gravels are seldom durable enough to be used as road base or concrete aggregate.

Quaternary deposits (Qc, Qt, Qm, Qal, Qso, Qs). Sediments laid down since the Pliocene Epoch, exclusive of the Paso Robles Formation, are virtually unconsolidated. The deposits are mostly continental in origin, being confined mainly to the valleys and the Monterey Bay region. Probably the oldest distinctive unit among these is the Aromas Red Sands (Qc) which forms low hills bordering the lowlands of Monterey Bay. The formation consists typically of coarse, reddish-brown sands, but also contains some gravel and clay. Deposition took place under fluviatile and eolian conditions.

More widely distributed are gravel, sand, silt and clay of the stream channel and floodplain deposits (Qal). Dissected flood plain and fan deposits that flank the streams and rivers are older and are designated as "Qt" on the map. Along the coast, marine terrace deposits (Qm) reflect numerous Pleistocene changes in sea level. The present shorelines are fringed by Recent beach and dune sand deposits (Qs), and

Photo 11. View northeast across Peach Tree Valley toward Mustang Ridge. Southwest slope of ridge exposes soft, highly-dissected, Pliocene marine and Plio-Pleistocene non-marine formations. These are separated by segments of the San Andreas fault from Franciscan rocks exposed at the crest of the ridge.

Photo 12. Looking east from Presidio of Monterey across southern Monterey Bay. Recent sand dunes flank the Bay and granitic rocks form the northern Sierra de Salinas in distance. Low hills in middle distance are underlain by late Cenozoic sedimentary formations and higher hills to right (south) are developed in the Monterey Formation. *Rey Ruppel photo, courtesy Monterey Peninsula Chamber of Commerce.*

older sand dunes (Qso) cover larger areas in the vicinity of Fort Ord and King City.

Some of the stream deposits are important sources of sand and gravel used as concrete aggregates and road construction materials. Terrace and fan deposits, as well as Aromas Red Sands, also have been utilized, but to a lesser extent. More important are the Recent beach and dune deposits which provide large amounts of sand for specialty and construction purposes. Alluvial clay from the Salinas Valley was used for many years to manufacture tile and common brick, and adobe soil from a stream terrace deposit was the source material for a past adobe brick operation. Placer gold also has been obtained in small quantities from stream deposits in the Santa Lucia Range and Cholame Valley.

STRUCTURAL FEATURES

The rocks of Monterey County have been subjected to repeated periods of faulting, folding and downwarping, rendering the region one of the most geologically complex in California. In spite of the complexity, the major structural features and the topographic units defined by them are persistently aligned in a northwest direction. Smaller faults and folds, as well as distribution of lithologic units, generally parallel the major structural trends. Some of the more important structures are described below. The main faults are shown on the geologic map (Plate I).

Faults. One of the most prominent fault features is the northwest-trending San Andreas fault zone that crosses the eastern part of Monterey County, separating the Diablo Range on the east from the Gabilan Range and Cholame Hills on the west. Consisting of a series of subparallel faults, the zone is as much as several miles wide and can be traced more than 600 miles from the Salton Sea, Imperial County, to Point Arena, Mendocino County. Displacement along the zone has been strike slip in a right-lateral sense, with the northeast block (Diablo Range) moving southeast in relation to the southwest block (Gabilan Range and Cholame Hills). Various faults that comprise the San Andreas fault zone probably were active as early as Late Jurassic or Early Cretaceous time and periodic movements since then have continued to the present time. Displacement in recent geologic time is measured in miles and some geologists believe cumulative dislocation to be in the order of a few hundred miles (see Crowell, 1962, p. 17–25, for review of fault displacements described in the literature).

Another important zone of faulting is the Nacimiento-Sur fault zone which includes the Nacimiento, McWay, Sur and related faults. This northwest-trending zone extends about 200 miles from northwestern Ventura County to the Little Sur River where it crosses the coastline and extends under the ocean for an unknown distance. Not much is known concerning movements along the fault zone, except at the north end where the Sur and McWay thrusts are mapped as thrust or reverse faults with the northeast block over-riding the southwest block. The central and southern faults of the zone are generally thought to be right-lateral like the San Andreas, but there is little proof for this conclusion. The San Andreas and Nacimiento fault zones are of particular significance in that they define a fault block or region underlain by Sur Series metamorphic and Santa Lucia granitic rocks which have not been recognized in adjacent terrane beyond the limits of the fault zones. Conversely, the Franciscan Formation, which constitutes the known "basement" in the adjacent regions, is not recognized between the two major fault zones.

Many other important faults have been mapped and no doubt some have not yet been recognized. A large number of major faults, mainly of reverse type, exist in the Santa Lucia Range, breaking that range into a multitude of fault blocks. Surprisingly, only a few faults are recognized in the Gabilan Range and Cholame Hills to the east. The Gabilan Range-Cholame Hills region appears to have acted as a unit or single fault block during much of the recorded geologic history. This block probably is bounded on the southwest by at least one buried fault which underlies and parallels the Salinas Valley. Such a fault, termed the King City fault (Kilkenny, 1948, p. 2264; Gribi, 1963, p. 20), must have been active during early to middle Tertiary time to account for the structural and stratigraphic differences on opposite sides of the Salinas Valley.

Additional faults, especially high-angle reverse and thrust types, are found in the Diablo Range and at the northern end of the Gabilan Range. From an economic viewpoint, faults and related fractures have controlled the mineralization of gold and mercury minerals (e.g. in the Los Burros district and Table Mountain area).

Folds. Regional synclines that represent remnants of troughs where thick sequences of marine sediments were deposited, are believed to be the largest folds in Monterey County. The largest of these synclines extends southeastward along the southwest side of Salinas Valley south of Greenfield. Because of superimposed folds, this large feature is not recognizable at the surface, but is still preserved beneath the surface. A probable continuation of the syncline can be traced northwesterly between the Sierra de Salinas and Santa Lucia Ranges to Carmel Valley. Regional synclines originating at earlier geologic times largely have been destroyed by mountain building processes.

Smaller folds also are found but are too numerous to be described individually. Generally speaking, folding has been intense in the Upper Cretaceous and Tertiary except in the southern Gabilan Range-Cholame Hills area where folds are mostly gentle. Anticlinal structures have been responsible for the accumulation of oil at San Ardo field and at most of the small fields to the northwest in Salinas Valley.

Photo. 13. View northeost from Chews Ridge toword Sierro de Solinos. The low hill region between the Sierra de Solinos ond Sonto Lucio Ronge is a lorge syncline, believed to be a remnont of Miocene seowoy thot once connected the Solinos Valley with the coost. *Photo by Mory Hill.*

Mines and Mineral Deposits

The total recorded value of minerals produced in Monterey County from 1889 to 1964 amounts to $386,704,916. Of this, the fuels accounted for more than 60%, industrial minerals nearly 39%, and metallic minerals about 1%. The most important commodities—petroleum, dolomite and dolomitic lime, magnesium compounds, sand and gravel (including glass sand, feldspar, silica and other specialty sands), natural gas, stone and salt—accounted for more than 99% of the total mineral production.

Just how rapidly the mineral industry has expanded during the last 25 years is illustrated in Figure 2, which illustrates that the total value of minerals produced during the 1940–1944 period is equal to the entire mineral production of the preceding 50 years. The spectacular increases in production in succeeding five-year periods largely reflect the establishment and subsequent expansion of the refractories industry (dolomite, dolomitic lime, magnesium compounds) and development of the San Ardo oil field following completion of oil pipeline facilities. Added demands for construction and specialty sands since World War II and construction of natural gas pipelines since 1956 also have played important roles in the expansion of Monterey County's mineral production.

In addition to the recorded production, several minerals were produced in substantial but unrecorded

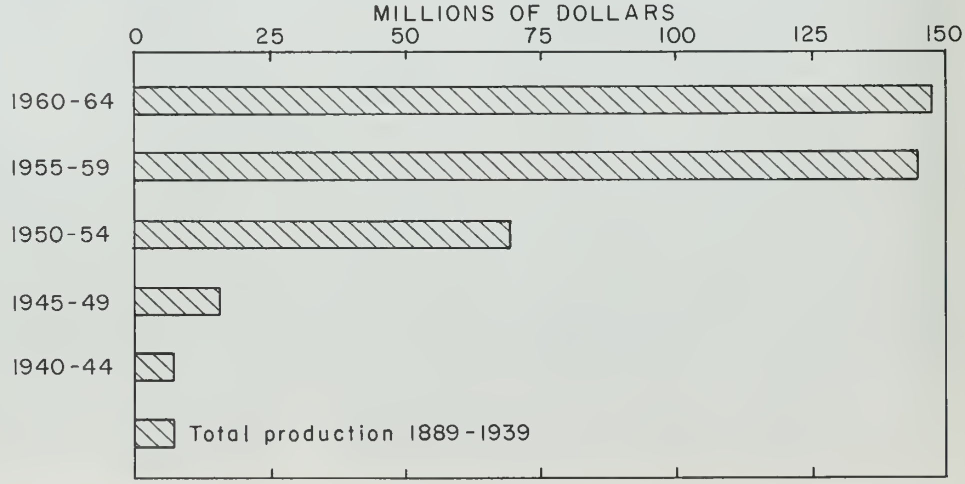

Figure 2. Minerol production of Monterey County: the totol minerols produced in 5-yeor periods, 1940–64.

Table 2. Mineral production of Monterey County, 1889–1964 *

Year	Gold	Silver	Diatomite		Brick and Clay		Lime		Limestone		Mineral Water		Glass Sand		Miscellaneous stone[1]		Miscellaneous and unapportioned			Totals
	Value	Value	Tons	Value	M or tons	Value	Barrels	Value	Tons	Value	Gallons	Value	Tons	Value	Tons	Value	Amount	Value	Substance	
1889	$3,500																			$3,500
1890	11,815																			11,815
1891	2,755																			2,755
1892																				
1893																				
1894	8,000															$1,500				9,500
1895																				
1896											5,000	$1,000								1,000
1897					Brick (M):				2,000	$2,000	2,000	200								2,200
1898					400	$2,400			2,049	1,640	21,000	1,050				14,025				19,115
1899					200	1,400			7,744	6,970	1,500	750				8,258	43 tons	est. $500	Asphalt	17,878
1900					200	1,600			8,000	10,800	20,000	4,000				2,775				19,175
1901	13,800								5,463	7,500	15,000	3,250	4,500	$15,750		8,869	200 tons	1,000	Coal	50,169
1902	6,860	$18					22,000	$13,200			15,000	1,750	4,500	12,225		5,200				39,253
1903	11,419	15					26,000	23,400	6,516	9,000	55,000	1,250	5,989	4,967		3,167	61 tons	732	Asphaltum	53,950
1904	7,668				200	1,600	3,240	3,240	4,550	21,500	25,000	1,000	8,295	7,272			124 tons	1,488	Asphaltum	43,768
1905	4,000						10,000	10,000			5,000	1,000	9,257	8,127						23,127
1906	625	3	80	$400			40,000	50,000			24,000	12,000	750	1,125						64,153
1907	1,076	9					109,000	125,000			120,000	12,000	11,065	8,178			4,800 tons	24,000	Coal	170,263
1908	1,318	12			426	3,838	50,000	50,000					6,805	5,120		31,727	7 flasks	296	Mercury	92,311
1909	333	5	500	3,500	300	2,900	50,006	62,508	10,658	45,678	10,000	2,000	6,496	4,872		43,351	1 flask	49	Mercury	165,196
																		314,789	Unapportioned 1900–1909 (coal, gold, etc.)	344,789
1910	121	2	500	3,500	993	9,957	30,894	29,349	2,500	7,500			7,594	5,890		47,487	7 flasks	317	Mercury	
																	700 tons	5,000	Feldspar	111,623
					Clay (tons):												200 tons	2,500	Fuller's earth	
1911			850	5,950	1,100	4,950			2,000	6,000			[2]			27,011		40,572	Coal, feldspar, glass sand	84,483
1912	3,435	23	[2]		4,000	6,000			6,000	8,000	20,000	7,000	9,016	7,916		60,119		30,900	Coal, feldspar, fuller's earth, diatomite	123,393
1913	6,491	27	1,700	6,800	3,500	12,000			6,500	13,000	20,000	7,000	9,141	9,192		12,556		78,332	Coal, feldspar, fuller's earth	145,398
1914	4,424	19	2,700	9,540							26,000	7,900	9,210	7,633		40,180	5,992 tons	17,976	Coal	94,322
																	700 tons	3,500	Feldspar	
																	450 tons	3,150	Fuller's earth	
1915			[2]								8,200	2,050	[2]			42,449		40,487	Coal, feldspar, diatomite, mercury, glass sand	84,986
1916			[2]								5,900	590	[2]			62,223		50,659	Barite, feldspar, diatomite, mercury, salt, glass sand	113,472
1917			[2]						[2]				[2]			57,810	6,392 tons	23,468	Dolomite	
																		57,508	Barite, diatomite, limestone, mineral water, salt, mercury, glass sand	138,786
1918			[2]										[2]			52,697	4,900 tons	25,950	Dolomite	
																	700 tons	3,800	Feldspar	119,687
																		37,240	Barite, coal, diatomite, mercury, salt, glass sand	
1919			[2]										[2]			73,031	8,280 tons	29,120	Dolomite	145,504
																		43,353	Barite, coal, feldspar, diatomite, salt, glass sand	
1920			[2]								200	20	[2]			84,056	5,755 tons	26,238	Dolomite	126,449
																		16,135	Barite, coal, feldspar, diatomite, salt, glass sand	
1921			[2]								[2]		[2]			63,316	2,500 tons	8,750	Dolomite	
																		98,089	Asbestos, coal, diatomite, mineral water, glass sand, salt	170,155
1922													[2]			86,180		169,139	Asbestos, coal, dolomite, mercury, salt, glass sand	255,319
1923			504	8,805							[2]		[2]			140,724		72,493	Asbestos, dolomite, mineral water, mercury, salt, glass sand	222,022

Table 2. Mineral production of Monterey County, 1889–1964—Continued

Year	Gold	Silver	Diatomite		Brick and Clay		Lime		Limestone		Mineral Water		Glass Sand		Miscellaneous stone[1]		Miscellaneous and unapportioned			Totals
	Value	Value	Tons	Value	M or tons	Value	Barrels	Value	Tons	Value	Gallons	Value	Tons	Value	Tons	Value	Amount	Value	Substance	
1924			[2]		238	436					[2]		[2]			239,847	1,240 tons	4,960	Dolomite	286,490
																		41,247	Diatomite, mineral water, mercury, salt, glass sand, building stone	
1925	998	3	1,689	22,638	414	1,161							[2]			209,423		43,498	Mercury, salt, building stone, glass sand	277,721
1926	706	3	3,110	45,987	491	1,164							[2]			263,244		48,889	Dolomite, salt, building stone, glass sand	359,993
1927	500	2	3,402	47,559	1,100	550							[2]			244,584		57,854	Dolomite, mercury, salt, building stone	351,049
						Total: 49,956	Total: 332,140	Total: 366,697	Total: 63,980	Total: 139,588	Total: 398,800	Total: 65,810								
					Sand and gravel[4]		Building stone		Petroleum		Natural gas									
					Tons	Value	Cu. ft.	Value	Barrels	Value	1,000 cu. ft.	Value								
1928	898		6,723	76,505	[5]		94,700	$22,200								210,489		42,466	Clay (pottery), dolomite, salt	352,558
1929	263	1	4,707	41,392	[5]		80,200	11,900					[2]			213,082		88,220	Clay (pottery), dolomite, salt, glass sand	354,858M
1930			[2]		[5]		120,300	32,500					[2]			233,971		186,503	Asbestos, clay, diatomite, dolomite, mercury, salt, glass sand	452,974
1931	148	1	[2]		[5]		96,400	26,480					[2]			138,032		141,744	Clay, dolomite, coal, salt, diatomite, glass sand	306,405
1932	794	1	[2]		[5]		37,533	10,560			[2]		[2]			95,802		59,140	Coal, diatomite, dolomite, natural gas, salt, glass sand	166,297
1933	195		[2]		[5]		[2]				[2]		[2]			64,107		49,738	Clay, coal, diatomite, dolomite, mercury, natural gas, glass sand, building stone	114,040
1934	517	1	[2]		[5]		[2]				[2]		[2]			101,652		88,732	Clay (pottery), coal, diatomite, dolomite, natural gas, mercury, salt, building stone, glass sand	190,902
1935	297	1	[2]		[5]		31,401	4,370			[2]					61,261		66,760	Coal, diatomite, dolomite, gemstones (jasper), natural gas, mercury, salt	132,689
1936	[2]	[2]	[2]		[5]		44,820	7,900			[2]					130,590		48,882	Diatomite, dolomite, gemstones (jasper), gold, mercury, natural gas, salt, silver	187,372
1937	1,960	3	[2]		[5]		51,300	8,150			[2]		[2]			206,700		45,848	Diatomite, dolomite, mercury, natural gas, salt, glass sand	262,661
1938	2,135	3	[2]		[5]		[2]				[2]		[2]			151,888		33,118	Diatomite, gemstones, mercury, natural gas, salt, glass sand, building stone	187,144
1939	[2]	[2]	[2]		[5]		35,672	6,737			[2]		[6]			178,092	11 flasks	1,151	Mercury	
																		41,320	Diatomite, dolomite, gold, natural gas, salt, silver	227,300
1940	[2]	[2]	[2]		[5]		[2]						[6]			257,691	42 flasks	6,972	Mercury	304,677
																		40,014	Diatomite, gemstones, gold, silver, salt, building stone	
1941	595	5	[2]		[5]		[2]						[6]			360,162		54,303	Diatomite, dolomite, mercury, salt, building stone	415,065
1942			[2]		[5]		[2]						[6]			221,239		689,443	Diatomite, dolomite, magnesia, mercury, salt, building stone	910,682
1943					[5]		[2]						[6]			587,681		2,463,162	Dolomite, magnesia, mercury, salt, glass sand, building stone	3,050,843
1944					[5]		[2]						[2]			414,595		2,284,246	Dolomite, magnesia, mercury, salt, glass sand, building stone	2,698,841
1945					[5]		[2]						[2]			691,303		2,275,977	Dolomite, magnesia, salt, glass sand, building stone	2,967,280
1946					352,649	$225,775	[2]						[2]					1,766,648	Dolomite, magnesia, salt, glass sand, building stone	1,992,423
1947					646,973	1,022,058	[2]		737	$1,024			[2]		147,730	232,980		1,724,259	Dolomite, dolomitic lime, magnesium compounds, salt, ground sand, building stone	2,980,321
1948	840	5			808,160	1,525,600	[5]		119,000	239,000	7,517	[3]$752	[6]		197,150	281,166		2,150,144	Dolomitic lime, magnesium compounds, salt, ground sand	4,197,507

Table 2. Mineral production of Monterey County, 1889–1964—Continued

Year	Gold	Silver	Diatomite		Brick and Clay		Lime		Limestone		Mineral Water		Glass Sand		Miscellaoeous stone[1]		Miscellaneous and unapportioned			Totals
	Value	Value	Tons	Value	M or tons	Value	Barrels	Value	Tons	Value	Gallons	Value	Tons	Value	Tons	Value	Amount	Value	Substance	
1949	140	1			775,084	1,248,268	[2]		480,000	616,000	5,255	500	[6]		131,710	231,297		1,810,157	Dolomitic lime, magnesium compounds, salt, building stone, ground sand	3,906,363
1950	735	4			825,254	1,544,405	[2]		187,979	193,619	6,000	620	[6]		[2]			3,095,435	Dolomite, dolomitic lime, magnesium compounds, salt, building stone, decomposed granite, glass sand	4,834,818
1951					878,022	1,543,582	[5]		2,746,916	2,973,108	118,337	11,800	[6]		79,050	87,914		2,438,603	Dolomite, dolomitic lime, magnesium compounds, salt, silica sand	7,055,007
1952					815,752	1,695,815	[2]		8,286,585	9,198,100	299,120	48,213	[6]		[2]			4,579,335	Chromite, dolomite, feldspar, dolomitic lime, magnesium compounds, salt, silica sand, stone	15,521,463
1953	140	3			1,114,261	2,786,154	[5]		11,320,075	13,707,137	1,040,629	156,094	[6]		57,293	62,125		5,670,370	Dolomite, feldspar, dolomitic lime, magnesium compounds, salt, ground and foundry sands	22,382,023
1954					1,073,455	2,381,204	[5]		11,213,000	13,587,000	1,336,892	214,000	[6]		101,013	240,139		3,415,645	Dolomite, feldspar, dolomitic lime, magnesium compounds, salt	19,837,988
1955					631,173	1,411,625	[5]		10,972,000	16,425,890	3,377,000	[3]743,000	[6]		61,143	267,621		4,847,211	Feldspar, dolomitic lime, gemstones, magnesium compounds, salt, silica sand	23,695,347
1956					667,299	2,062,709	[2]		11,733,000	18,890,000	4,169,000	901,000	[6]		[2]			6,449,065	Chromite, feldspar, gemstooes, dolomitic lime, magnesium compounds, mercury, salt, stone (crushed & dimension)	28,302,774
1957					887,770	1,538,859	[5]		11,845,000	23,659,000	4,229,000	918,000	[6]		70,674	284,407		6,972,055	Chromite, feldspar, gemstones, dolomitic lime, magnesium compounds, mercury, salt	33,372,321
1958					412,370	1,104,405	[5]		10,864,728	19,405,218	3,315,000	770,336	[6]		185,310	519,483		5,734,504	Chromite, feldspar, gemstones, dolomitic lime, magnesium compounds, mercury, salt	27,533,946
1959					1,046,816	1,919,324	[5]		10,995,000	17,224,000	3,074,000	711,311	[6]		186,011	544,189		7,432,028	Feldspar, gemstones, dolomitic lime, magnesium compounds, mercury, salt	27,830,852
1960					832,282	1,928,074	[2]		11,589,000	17,888,000	3,546,000	947,000	[6]		[2]			7,873,509	Feldspar, gemstones, dolomitic lime, magnesium compounds, salt, stone (crushed & dimension)	28,636,583
1961					587,600	1,690,092	[2]		11,865,000	18,113,000	4,375,000	1,238,000	[6]		[2]			8,970,138	Feldspar, gemstones, dolomitic lime, magnesium compounds, salt, stone (crushed & dimension)	30,011,230
1962					815,082	1,771,497			11,230,000	17,642,695	5,647,000	1,637,494	[6]		[2]			8,489,564	Feldspar, gemstones, dolomitic lime, magnesium compounds, salt, stone (crushed)	29,541,395
1963	105	1			942,701	1,796,884			10,171,000	15,850,078	4,609,000	1,350,308	[6]		[2]			9,326,742	Feldspar, gemstones, dolomitic lime, magnesium compounds, salt, stone (crushed)	28,324,431
1964					1,006,000	2,042,000			10,233,805	15,649,358	3,941,164	1,178,406	[6]		[2]			10,251,003	Feldspar, dolomitic lime, maguesium compounds, salt, stone (crushed)	29,120,767
Totals	$99,606	$171	26,465	$272,576	15,118,703	$31,238,330			145,852,825	$221,262,227	43,095,914	$10,826,834	92,618	$98,267	1,217,084	$8,995,467		$113,158,132		$386,704,916

* Data prior to 1944 adapted from Calif. Div. of Mines Bull. 130, pp. B-64-B-67, with minor adjustments. Data 1944–1961 after U.S. Bureau of Mines, with adjustments as indicated.
[1] Includes sand and gravel (excepting glass sand) prior to 1946.
[2] See under Unapportioned.
[3] Value estimated by author; volume figures from Calif. Div. Oil and Gas.
[4] Includes sandblasting, foundry, engine and other specialty sands (including some glass sand), as well as construction sand and gravel. Prior to 1946, Sand and Gravel included with Miscellaneous Stone.
[5] Included with Miscellaneous Stone.
[6] Mostly included with Sand and Gravel, but some years partly included with Unapportioned under various designations (silica sand, glass sand, ground sand, feldspar).

amounts, mainly before 1889. These include sand, limestone and lime, stone, coal, clay (for adobe and tile), and gold. Minor unrecorded amounts of bituminous sandstone, mercury, gemstones and silver also have been produced. It is not possible to estimate accurately the amount of unrecorded mineral production, but it may aggregate several million dollars. Additional information on unrecorded production is given below under the separate sections on mineral commodities.

Table 2 lists the recorded mineral production for the county by years and commodities; many of the figures are combined in order not to reveal production of individual producers. Also, a few corrections have been made by the author where published records are known to be in error. For example, gypsum production previously credited to Monterey County actually came from San Benito County, and therefore production figures have been dropped from the tabulation. Minor revisions likewise have been made with regard to petroleum, natural gas, and mercury. Although some errors and omissions certainly exist during the early years, Table 2 provides a reasonably valid picture of Monterey County's mineral history from 1889 to 1964.

All of the significant known mineral deposits, developed and undeveloped, in Monterey County are described alphabetically by commodities in the following text. Additional data for other mining and mineral deposits are given in the tabulation at the end of this report. The tabulation lists, alphabetically by commodities, all mines and quarries known to the author, and therefore it may be used as an index.

ARSENIC

Arsenic, mainly in the form of arsenopyrite, is known from two areas—the Los Burros district and Riley Ranch—and probably occurs elsewhere in Monterey County. Arsenopyrite has been reported from many mines and prospects in the Los Burros gold district. Here it occurs locally as finely-divided crystals disseminated in quartz veins and associated slaty gouge. The percentage of arsenic in these veins, possibly with minor exceptions, is believed not to exceed a few percent at most. Not all of the auriferous veins in this district contain arsenopyrite. Although a minor amount of arsenic has been mined along with primary gold ore in some mines (e.g. Buclimo and New York mines), no production of arsenic is recorded. The Riley Ranch prospect at one time was considered to be a potentially commercial arsenic deposit (Laizure, 1925, p. 28) and apparently was prospected in a minor way for that reason. Here, arsenopyrite, associated with magnetite and copper oxides, was reported along a contact metamorphic zone between limestone and granitic rock, but no production has been recorded.

In 1924, the price of arsenic fell from 13½¢ to 6½¢ per pound and has remained low to the present time. Since then, arsenic has been considered a nuisance by refineries, and ores containing it are penalized. Arsenic is recovered principally as a matter of necessity in the smelting and refining of other ores. There is little or no market for arsenic ores in California.

ASBESTOS

Asbestos is a commercial name applied to chrysotile and to several minerals of the amphibole group which are of commerical importance because of their fibrous characteristics. The varieties of amphibole asbestos include the minerals tremolite, actinolite, crocidolite, amosite, and anthophyllite, which differ in their chemical and physical properties as well as in their modes of occurrence (Rice, 1957, p. 49). These varieties are not known to occur commercially in Monterey County.

Chrysotile (hydrous magnesium silicate) is the most important type of asbestos because it is relatively abundant, and its silky fibers are highly flexible and have good tensile strength. The mineral fibers can be used in a wide variety of industrial applications where these properties are desirable. Commercial chrysotile occurs as cross and slip fibers in veins and veinlets in serpentine, a secondary rock derived mainly by alteration of peridotite.

Three chrysotile asbestos prospects are known in Monterey County. Two of the prospects—near Burro Mountain and at Willow Creek—are described below. The third is on the south side of Table Mountain where Johns-Manville Corporation has located claims and leases in the vicinity of sec. 30, T. 23 S., R. 16 E. This prospect is said to be similar to deposits northwest of Coalinga, Fresno County, where matted, short fiber asbestos ore is presently being mined and processed. Only a minimum amount of exploration work had been done as of March 1963. Other asbestos prospects may exist in serpentine bodies in the southwest and southeast regions of the county. Serpentine bodies are shown on the geologic map (Plate I) as "ub".

Only minor amounts of chrysotile have been produced and all of that has been for testing purposes. In April 1963, Union Carbide Corporation began construction of an asbestos processing plant at Welby Station, 5 miles southeast of King City. The company plans to process short fiber chrysotile ore trucked from their deposit northwest of Coalinga.

Burro Mountain prospect. Location: S¼ sec. 2 and SE¼ sec. 3, T. 24 S., R. 6 E., M.D., 4 miles by jeep road and 14 miles by all weather road southwest of Jolon. Ownership: Asbestos Development, Inc., 1251 Ingraham St., Los Angeles, owns about 4 square miles of unpatented claims in secs. 1, 2, 3, 11 and 12, T. 24 S., and sec. 35, T. 23 S., R. 6 E.

This deposit was first developed in 1920 by Walter R. Harris of Bryson and J. E. Barrett of San Luis Obispo. They continued to develop the prospect by open cuts and adits until 1923, making several small shipments to the U. S. Asbestos Company, Downey,

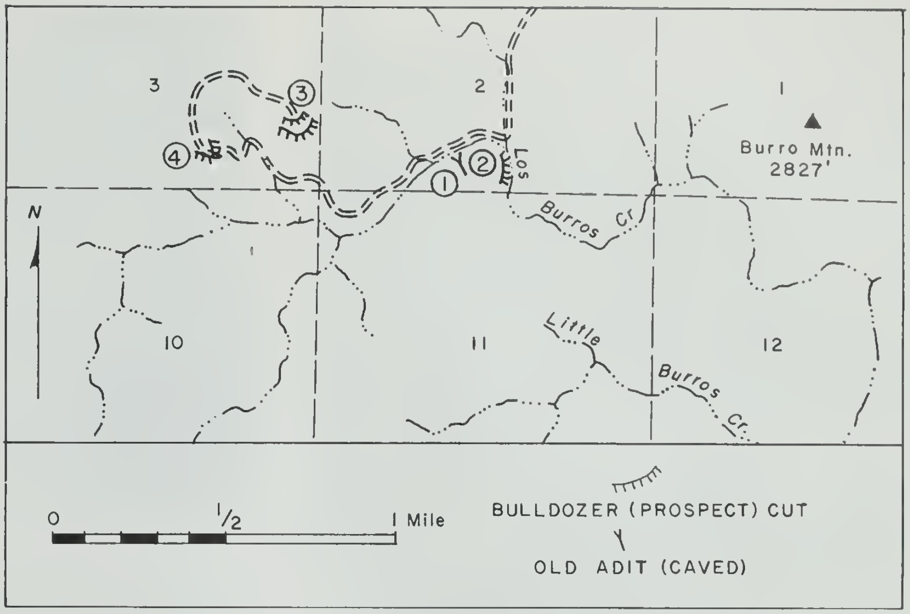

Figure 3. Burro Mountain asbestos (chrysotile) prospect (T. 24 S., R. 6 E., Burro Mountain 7½' quadrangle).

for testing (Laizure, 1925, p. 28). Additional exploration and testing apparently was done in 1930, but did not result in commercial production. Many years later Asbestos Development, Inc., acquired the prospect and developed additional cuts. In 1953 and 1954, samples were reported tested, but apparently no development work has been done since then.

The recent claims cover the northwest salient of a large northwest-trending mass of peridotite that is serpentinized in the vicinity of the deposit. This mass is complexly intruded into greenstone, chert, and sandstone of the Franciscan Formation. The chrysotile occurs as cross-fibered veins and veinlets in shear zones in the serpentine. The shear zones and larger veins generally strike west-northwest and dip steeply to the north.

The prospect has been developed by several bench cuts and a cross-cut adit (see map, Figure 3). The adit was part of the early development and is now completely caved. It is located on the south bank of southwest tributary to Los Burros Creek (#1) and was driven south, apparently into the main chrysotile zone. Four bulldozer cuts, made or continued around 1953, expose chrysotile veinlets in three places in sheared serpentine. These shear zones as seen in three of the cuts contain an estimated 5–10% chrysotile in fibers, in places up to one-half inch long. The fourth cut (#4) is nearly barren. Most of the chrysotile is less than ¼ inch long, and more work is necessary to determine if a commercial tonnage of asbestos ore really exists. Expense of processing in, and hauling from, this remote area would necessitate a large scale operation. However, it is not certain if any mining could be conducted under present circumstances, as the prospect lies within the Hunter Liggett Military Reservation.

Willow Creek prospects. Location: Secs. 30, 31, and NW¼ 32, T. 23 S., R. 5 E., M.D., traversed by State Highway 1. Ownership: George Gaul, 5901 Montgomery Drive, Santa Rosa, applied for a lease from U.S. Bureau Land Management in December 1959.

Short fiber chrysotile asbestos occurs in several serpentine masses in the vicinity of Willow Creek (S. J. Rice, oral communication, 1960). Locally, high concentrations of cross-fiber chrysotile are exposed in the sea cliffs north and south of Willow Creek in secs. 30 and 31. Both cross-fiber and slip-fiber varieties occur in serpentine along Willow Creek in NW¼ sec. 32. Prior to 1960 there was no exploratory development. Prospect development west of State Highway 1 probably would not be permitted due to the proximity of the road to the steep cliffs.

Photo 14. White dumps from barite workings on Rocky Ridge, a west extension of Fremont Peak. Barite occurs along brecciated zones of silicified dolomitic limestone which crop out prominently at the crest of the ridge. *Reprinted from Bowen and Gray 1959, photo 34.*

BARITE

The only known deposits of barite (barium sulfate) in Monterey County are found along the ridge extending westward from Fremont (Gabilan) Peak. Barite occurs as replacement pods or veins in silicified limestone and dolomite. Similar barite deposits may exist elsewhere in the county in the crystalline limestone and dolomite rocks, but none have been reported. Part of the reason for this may be that barite, which is frequently white to light gray in color, closely resembles crystalline limestone or dolomite in the field. However, with a specific gravity of 4.3 to 4.6, it is much heavier than limestone and other common rock material and can be discerned by its heft.

Fremont Peak deposit. Location: SE¼ sec. 34, T. 13 S., R. 4 E., M.D., just west of Fremont Peak and about 12 miles by road south of San Juan Bautista. Ownership: Bardin Ranch (part of the original Cienega del Gabilan Rancho grant).

Small deposits of barite occur for a distance of nearly one mile on the ridge extending west from Fremont Peak. This area has been prospected by 3 northwest-trending adits and several shallow prospect pits. The main development work was done about 1,500 feet west of the peak on the Bardin Ranch, but minor barite prospects 800 feet west of the Peak lie within Fremont Peak State Park. Other prospects are found 800 and 2,500 feet west of the main workings.

Bradley and Logan (1917, p. 624) reported that this barite deposit was first developed in 1915 when L. H. Day and H. W. Underwood of Hollister made a few

Photo 15. Closeup of white crystalline barite veins and replacement salients cutting gray dolomitic limestone west of Fremont Peak. Formation of the barite is probably related to granitic intrusions which occurred nearby. *Reprinted from Bowen and Gray, 1959, photo 35.*

shallow prospect cuts. According to Mr. Day, two assays of barite showed 98.6 percent and 99.7 percent barium sulfate. Later in 1915, W. A. Farish, Jr., of San Francisco began opening the deposit for production in the succeeding years. The lease apparently changed hands again about 1918, when A. R. Haskins of Hollister acquired control of the deposit from J. and H. Bardin (unpublished records and Boalich, 1921, p. 156). The deposit was last active in 1920. In all,

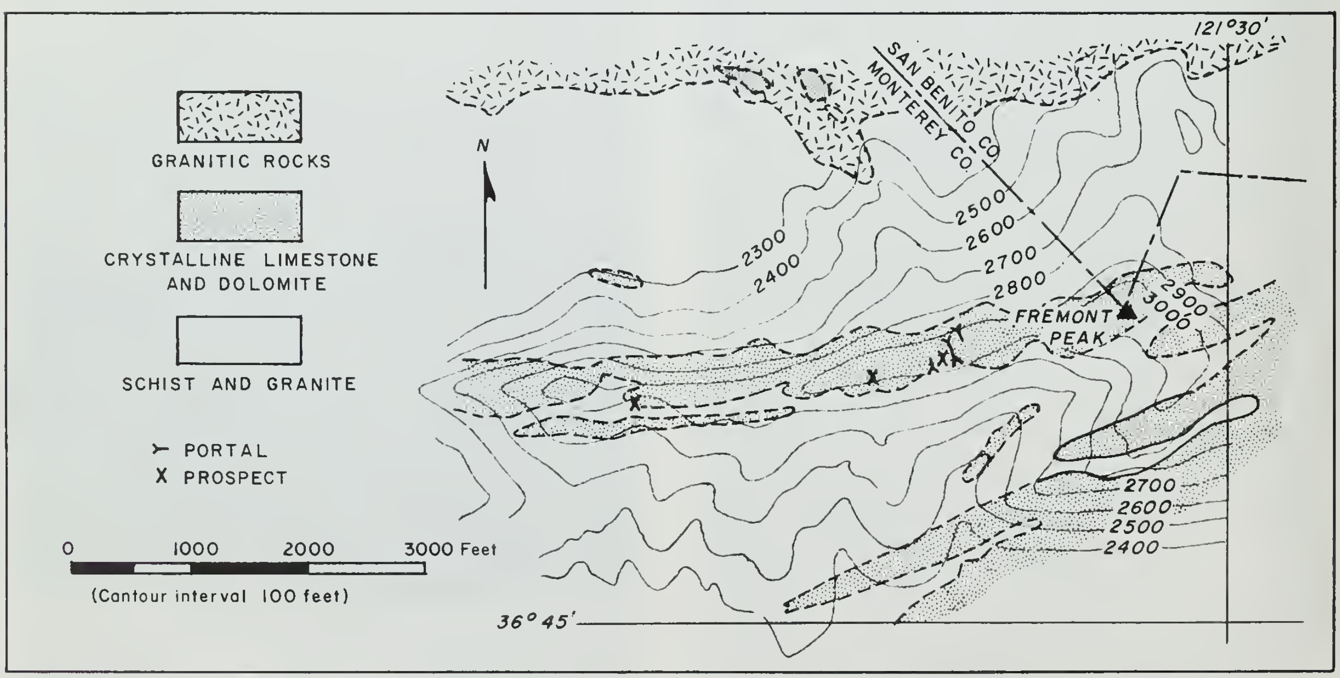

Figure 4. Geologic map of Fremont Peak, showing locations of barite workings (data simplified from Bowen and Gray, 1959, pl. 1).

the Fremont Peak deposit was productive from 1916 to 1920, yielding 2,701 short tons of barite valued at $31,157. This accounted for 25 percent of the total recorded barite production in California for that period. The following table shows yearly production figures for the deposit (from Bowen and Gray, 1959, p. 40):

Year	*Short tons*	*Value*
1916	225	$1,373
1917	1,226	11,034
1918	100	1,500
1919	1,000	15,000
1920	150	2,250
Total	2,701	$31,157

Bowen and Gray (1959, p. 39–40, and Pl. 1) have described the geology and mine development of the Fremont Peak barite deposit in considerable detail as follows:

"The barite is crystalline, white to gray in color, and ranges from fine to coarse grained. It occurs as pods or discontinuous veins which pinch and widen from 2 inches or less up to several feet and are complexly interwoven with silicified dolomitic limestone. The barite zones cut across the apparent bedding of the carbonate host rock, which in places is a very cavernous limestone with a notable development of light brown colored dripstone.

"The barite shows a characteristic banded structure. Well-defined barite vein material replaces dolomitic limestone and fades off into a replacement pattern in the carbonate rock typical of epithermal deposits. Low-temperature mineralization is also indicated by the absence of wollastonite and epidote.

"The principal mining centered in an area about 1500 feet west of Fremont Peak. Here an upper adit, stoped to the surface in places, was driven into the ridge from the north side at about N. 30° W. and opens into a large stope, open to the surface, on the south side of the ridge. The stope more or less parallels the ridge and is about 75 feet long, 25 feet wide, and of unknown depth. There is also a lower adit driven in the same direction about 150 feet, which probably was used to pull ore from the stopes. This adit was accessible in August 1955, but in need of some cleaning out. Below the stoped area is a zone of vuggy vein silica, probably a replacement of dolomitic limestone; dolomitic limestone lies above. Abundant barite and replacement silica, as well as dolomitic limestone, were found on the dumps.

"The deposits must have required selective hand mining methods, due to the interwoven nature of the barite, siliceous rock, and dolomitic limestone. Present market requirements are such that ore must be very selectively mined or ordinary mine-run material must be beneficiated. However, as reserves exposed in the workings are apparently small, neither course seems feasible. These conditions, coupled with the fact that part of the deposit lies within a state park, make it unlikely that further production will be made from this deposit."

BITUMINOUS SANDSTONE

Bituminous rocks have long been used in California as a source of natural asphalt concrete (macadam) for the paving of roads, driveways and walkways. Sandstone impregnated with asphalt is one of the most common materials used for this purpose and at least 2 such deposits were worked in Monterey County around the turn of the century. Total production of bituminous sandstone has been small in Monterey County and most of it has not been recorded. Published records of production are as follows:

Year	*Value ($)*	*Amount (tons)*	*Deposit*
1899	est. 500	43	San Ardo (?)
1903	732	61	
1904	1,488	124	
Totals	2,710	288	

In addition, production was obtained at the Mylar quarry from 1890 to about 1895. Also, several hundred wagon loads apparently were obtained from the San Antonio River deposit prior to 1918 (English and Kew, 1918, p. 240).

Bituminous rocks probably have little future potential as a paving material, because asphalt concrete made from manufactured asphalt and non-bituminous aggregate is more uniform and of higher quality than bituminous rocks, and unquestionably allows closer control of the physical properties required by construction specifications. Aside from paving, commercial uses of the bituminous sandstone deposits in Monterey County are difficult to visualize. It is possible that oily or tarry fractions of the larger and richer deposits can be obtained by surface mining and extraction methods or by underground (in-situ) combustion. A more remote possibility exists that the minor metals, especially uranium, contained in the bitumen may be of economic importance. W. J. Hail, Jr. (1957, p. 55–85) has sampled several bituminous deposits in Monterey County and the results of this study are tabulated in Table 3.

The most notable deposits of bituminous sandstone are the Mylar, San Antonio River, San Ardo, and King City deposits. These are described below. Other bituminous rocks and oil or tar seeps occur elsewhere, especially near Parkfield (English and Kew, 1918, p. 246–248).

King City deposit. Location: S½ sec. 28, NE¼ sec. 33, W½ sec. 34, T. 19 S., and sec. 3, T. 20 S., R. 7 E., M.D., 4 miles west of King City. Ownership: Not determined.

Tar sands are reported to occur in a sandy sequence that forms a transitional zone between Monterey siliceous shale and the overlying Santa Margarita sand-

Table 3. Oil and uranium contents of several bituminous sandstone deposits in Monterey County (data from Hail, 1957, table 3)

Deposit and sample numbers	Oil (percent of rock)	Ash in oil (percent)	Uranium in ash (percent)	Uranium in oil (ppm)	Location (Sec-T-R)	Position and thickness of bituminous sandstone bed sampled
San Lorenzo Creek (Mylar)						
97746	8.57	0.15	0.043	0.6	SE¼ 15–19S–9E	Middle of 13′ thick bed
97747	14.41	0.26	0.037	1.0	SE¼ 15–19S–9E	25′ above base; 30′ thick bed
97748	8.63	0.28	0.017	0.5	SE¼ 15–19S–9E	4′ above base; 30′ thick bed
San Ardo						
97749	3.58	0.60	0.072	4.3	SE¼ 13–22S–9E	16′ above base; 22′ thick bed
97750	8.90	0.39	0.064	2.5	SE¼ 13–22S–9E	4′ above base; 22′ thick bed
Bradley (San Antonio River)						
97751	10.49	0.44	0.045	2.0	SW¼ 35–24S–10E	5′ above base; 15′ thick bed

stone (Bramlette and Daviess, 1944, map sheet). The tar sands, which dip northeast and are locally thick, extend southeast from S½ sec. 28 to sec. 3. There is no known development of this deposit and analyses of the oil content have never been published.

Mylar quarry. Location: SE¼ sec. 15, T. 19 S., R. 9 E., M.D., 9 airline miles northeast of King City. Ownership: George W. Rist, King City (?).

The Mylar quarry is developed in a deposit of bituminous sandstone discovered about 1890 by Dr. Isaac Mylar and Thomas Mylar. During the next few years, some production (probably modest) was obtained for use in paving streets at King City by the Mylar Asphalt Company (Preston, 1893, p. 259; Crawford, 1896, p. 36). Little or no work has been done at the quarry since the turn of the century although the presence of the bituminous rock stimulated some nearby exploratory drilling for oil many years ago.

The bituminous sandstone has been described as an asphalt-bearing arkose which crops out over an area some 100 feet by 1,500 feet. Two quarries and several prospect pits mark the line of the northwest-trending deposit. The bituminous beds lie in the basal part of a marine Pliocene formation which is in fault contact with granitic rocks to the northeast. According to Hail (1957, pp. 61–62), the asphalt-impregnated beds are as much as 30 feet thick and dip about 14° SW. The oil analyses of 3 bituminous samples tested shows 8.57% to 14.41% oil in the sandstone (Table 3). The bituminous beds apparently extend to the south in the subsurface as they were penetrated 5 miles to the south by Texaco, Inc., Gabilan Mesa Core Hole 3 at a depth of 645–648 feet (Bramlette and Daviess, 1944, Table 1).

San Antonio River deposit. Location: SW¼ sec. 35, T. 24 S., R. 10 E., M.D., 6 miles southwest of Bradley. Ownership: Not determined.

The San Antonio River bituminous sandstone deposit has been known for many years, being first described by Goodyear in 1888 (p. 85–86). The only evidence of commercial development is south of the river where several hundred wagon loads of material were quarried from an open cut for local paving (English and Kew, 1918, p. 240). According to Hail (1957, Table 3) the bituminous sandstone occurs at the base of marine Pliocene rocks near the southwest corner of sec. 35. The Pliocene strata have been mapped and described by Taliaferro (1943, p. 460) as the Etchegoin Formation which lies unconformably on the Salinas Shale (Monterey Formation) of Miocene age. Others have described the bituminous beds as being part of the Paso Robles Formation and/or the Monterey Formation (e.g., Eldridge, 1901, p. 411–412; English and Kew, 1918, p. 240; Jennings, 1957, p. 61–62).

Regardless of the geologic age, the bituminous sandstone observed by this writer was about 20 feet thick and had a strike of N. 35° W. and a dip of 65° NE. This sandstone appeared to conformably overlie siliceous Monterey shale which was fractured, the fractures being filled with oxidized asphalt. Unconformably overlying the thin sandstone bed are sandstone and conglomerate beds of the Paso Robles Formation (?) which dip gently northeast and are somewhat bituminous in the basal portion. According to English and Kew (1918, p. 240), the deposit extends about one-quarter of a mile northwest and southeast of the roadcut exposure south of the river. An analysis of a bituminous sandstone sample showed the rock to contain 10.49% bitumen (Table 3). The bituminous material appears to be considerably oxidized at the surface.

San Ardo deposit. Location: Sec. 13, T. 22 S., R. 9 E. and sec. 18, 19, 20, 29, 32, 33, T. 22 S., R. 10 E., 2 miles southwest of San Ardo. Ownership: Not determined.

Bituminous sandstone beds crop out on the east flank of the San Antonio Hills from sec. 13 southeast to sec. 33, a distance of more than 5 miles. These beds, which dip variably to the northeast, are said to be richly impregnated with oil and tar in the lower horizons. According to English and Kew (1918, p. 245), the bituminous rocks are part of the Santa Margarita Formation which lies unconformably on siliceous shales of the Monterey Formation. Eldridge (1901, p. 410–411) has described the bitumen-impreg-

nated sequence as consisting of 125 feet of bituminous sandstone overlain by a 400-foot thick section of shale which in turn is overlain by interbedded shale and bituminous sandstone. This sequence has been assigned to a transitional zone between the Monterey and Santa Margarita Formations by Bramlette and Daviess (1944, map sheet).

As far as it is known, there has been no development of the San Ardo deposit, although the bituminous rocks have stimulated the search for oil nearby. Two samples of bituminous sandstone from a 22-foot thick bed in section 13 were analyzed and found to contain 3.58% and 8.90% oil (Hail, 1957, Table 3). (According to unpublished records, 43 tons of "solid" asphalt were produced near San Ardo in 1899, but it is not known if this came from the San Ardo deposit or elsewhere.)

CHROMITE

Chromite, a heavy black metallic mineral with a theoretical formula of $FeCr_2O_4$, is the principal ore of chromium. Deposits of chromite in Monterey County have been found only in serpentine or as "float" weathered out from serpentine in the Los Burros district of the Santa Lucia Range and in the Diablo Range. When found in place, chromite may be disseminated as grains, nodules, and stringers or may occur as relatively pure masses as pods, lenses, and various irregularly-shaped bodies. Both massive and disseminated types of ore have been mined in the county. Total recorded production to date is 705 short tons valued at $70,579, which is third in total value among the metallic mineral commodities in the county.

Although chromite prospecting has met with only minor success so far, the facts that chromite deposits have been found in widely scattered areas and that serpentine and peridotite-serpentine bodies occur throughout the southwest part of the county and the area east of the San Andreas fault zone suggest that further deposits of chromite probably exist. The geologic map (Plate I) shows the distribution of many ultrabasic rock (serpentine and peridotite) masses. These and other unmapped ultrabasic bodies associated with rocks of the Franciscan Formation are the best places to prospect for chromite ore.

Only 4 deposits have recorded production—these are the Lilly Group, Mee Ranch, South Slope, and Treasure Chest. Chromite has been reported in other parts of the county, notably as float on Table Mountain near Parkfield (Bailey, 1942, p. 160 and Laizure, 1925, p. 29) and as float at Evans Ranch in the southwest part of the county (Walker and Griggs, 1953, p. 54, 80).

Lilly Group. Location: N½ sec. 27, T. 24 S., R. 6 E., M.D., about 7 miles by jeep road northeast of State Highway 1 at the south county border in the Burro Mountain 7½-minute quadrangle. Ownership: Monte Young, P. O. Box 43, San Simeon.

The Lilly Group of claims consists of several unpatented lode claims extending for a length of one mile along the summit of a long N. 70° W.-trending ridge. The ridge crest is underlain by a narrow body of serpentine more than 3 miles long. The deposit apparently is a northwest extension of the Evans Ranch chromite deposit in section 26 (see Tabulated list). The chromite occurs as disseminated grains which are highly concentrated as nodules, stringers and pods. At one locality, the ore appeared to occur along shear zones that dip steeply to the north. The ore-bodies are small, varying in size from a few pounds to several tons, and are widely detached. Brown, iron-stained serpentine forms a halo around some of the ore-bodies and may prove a useful prospecting guide. However, the iron-staining is probably the result of weathering and may not exist more than a few feet below the surface. A pale green, compact variety of tremolite was noted as thin zones, probably resulting from shearing, in the vicinity of the ore-bodies but is not believed to be genetically related to the chromite. However, the chromite may have been localized along shear zones at the same time the tremolite was formed.

Mining of the chromite ore was done on a small scale from 1956 to 1958. The deposit was discovered by following chromite float up the south slope of the ridge on which it outcrops. The deposit was developed by shallow cuts using a bulldozer and some minor blasting to uncover and quarry the ore-bodies. By selective mining and hand sorting some of the higher-grade ore was shipped in lump form. The rest was milled and concentrated on a concentrating table. The grade of the ore and concentrates ranged between 44% and 49% Cr_2O_3 and one sample, reported at 47.4% Cr_2O_3, had a chromium-iron ratio (Cr/Fe) ranging from 2.2 to 3.0. The Lilly Group has been inactive since early 1958 when the General Services Administration closed the U. S. Government chromite stockpiling program. Little chromite was to be seen when part of the deposit was visited September 3, 1959, but scattered bodies of chromite ore might be expected at depth along the shear zones in a frequency similar to the small ore bodies previously found.

Mee Ranch deposit. Location: SW¼ sec. 9, T. 20 S., R. 11 E., M.D., in Cow Creek where crossed by State Highway 198, in the San Ardo 15′ quadrangle. Ownership: Mee Ranch, Peach Tree Valley.

In 1958, L. M. Andrus, M.D., of 202 King Place, King City, produced a moderately small amount of high-grade, massive chromite "float" from Cow Creek just downstream from State Highway 198. The chromite, which reportedly ran 53.6% Cr_2O_3 with a 3.1 Cr/Fe ratio, occurred in boulders weighing as much as several tons. Bright green uvarovite, a chromium-bearing garnet, is associated with this ore. Little chromite could be seen in the creek when visited in November 1959. The foreman of the Mee Ranch stated that about 15 tons of chromite also was obtained from the creek just above the road around 1953. However, the U. S. Bureau of Mines has no record of this earlier production.

Small serpentine bodies noted a short distance upstream from the chromite "float" are probably the source of the ore. This serpentine appears to lie within, but on the southwest side of, the San Andreas fault zone. Additional prospecting may be warranted in this area.

South Slope (Daisy, Aldelabran) Mine. Location: SW¼ sec. 29, T. 23 S., R. 6 E., M.D., in a small gulch tributary to Los Burros Creek in Alder Peak 7½-minute quadrangle. Accessible only with difficulty over many miles of dirt road from the east or west and on Hunter Liggett Military Reservation. Ownership: Joseph Holman, 1465 E. Orange Grove Avenue, Pasadena, owns one unpatented claim.

The South Slope mine apparently was first developed during World War I by the Daisy Chrome Company (Logan, 1918, p. 156). Walker and Griggs (1953, pp. 53–54, 80) reported the mine (then known as the Daisy deposit and owned by S. M. Mingus or A. Egenes) to be inactive and developed by a series of trenches and cuts exposing several pods of chromite ore ranging from 5 tons to 225 tons, plus a small tonnage scattered in stringers and gobs. Additionally 27 tons of ore were stockpiled. They further describe the deposit as follows:

> The ore bodies ore in a small sill-like mass of serpentine 100 ta 300 feet wide and 500 to 600 feet lang, striking N. 60° to 70° W. and dipping 60° to 80° NE. The ore accurs as a series of pads and stringers of high-grade chromite thot roughly parallel the strike and dip af the serpentine body. The pods are restricted ta a zane about 200 feet long, roughly parallel to the slope of the hill, with a vertical distance of about 50 feet between the highest and lowest pads. The grode of the are is estimated ot between 45 and 50 percent Cr_2O_3.

In 1952, Holman and Powell Paving Company mined by open pit methods virtually all of the known ore and shipped a high-grade product averaging 45 percent Cr_2O_3. Virginia Swanson of Salinas later acquired a lease from the present owner and obtained a small amount of high-grade ore at the southeast end of the deposit in 1957. The lump-ore shipped ran 44.7% Cr_2O_3 with Cr/Fe ratio of 2.6 and the concentrates from milling ran 43.9% Cr_2O_3 with a 2.3 Cr/Fe ratio. This ore was developed by a short adit, now partly flooded, but workings are not believed to be extensive.

When visited in 1959 by the author, no chromite ore could be seen in place in the highly sheared serpentine. However, a small amount of crushed, massive chromite ore on the floor of the pit was dark purplish-brown and iron-stained black. The purplish-brown ore is associated with emerald-green uvarovite and lavender kammererite, which are chromium-bearing garnet and chlorite, respectively. Additional chromite pods and stringers may be expected at depth, especially along the shear zones.

CLAY

Commercial deposits of high-grade clay, such as fire, china, and ball clays, have not been found in Monterey County. With one possible exception, all of the clay produced was common clay used to manufacture tile, brick, and adobe blocks. Fuller's earth, a type of non-swelling bentonite, reportedly (unpublished records) was produced during 1910–1914 by J. C. Jens, but this deposit has not been described in the literature, nor is its exact location known.

Common clay is a broad classification for a wide variety of impure or low grade clay materials suitable for use in one or more heavy clay products, including common brick, face brick, drain tile, sewer pipe, roof and floor tile, pottery, and adobe blocks. Raw materials have come mainly from alluvial and lake or ponded sediments, but may come from shales or from residual soils derived from many different rock types. Common clays are composed of various proportions of clay minerals, sand, silt, weathered rock and mineral fragments, and organic matter. The sand and iron oxide are generally desirable "impurities" in common clays because sand reduces shrinkage and plasticity, and iron oxide produces a red color when fired. Most soluble salts and calcite are usually undesirable impurities (Cleveland, 1957, p. 146).

Only a few common clay deposits have been developed in Monterey County and it might seem that such deposits are rare. However, if market conditions so demand, other deposits probably could be found without much difficulty in and bordering the Salinas Valley and its tributary system. According to state records, production of raw clay (1911–1913, 1924–1934) amounted to 12,139 tons vlaued at $27,082; fuller's earth (1910, 1912–14) amounted to 1,250 tons valued at $9,250; and brick (1898–1900, 1904, 1908–1910) amounted to 2,719,000 bricks valued at $23,691. This is a total of $60,023 for all clay products. Although no production has been recorded since 1934, clay for tile manufacture probably was produced since then, and adobe brick have been made from alluvium as recently as the early 1950's.

Brick

Brick was manufactured at the Salinas Brickyard by S. Pierce intermittently from 1898 to 1910. Aubury (1906, p. 250) states that the clay came from a pit at the south end of Abbot Creek (probably Alviso Slough now). The clay layer was reported to be 10 feet thick and the lower 4 feet was very plastic.

Tile

Tile (or brick-tile) probably was first manufactured by the Indians during the construction of the Carmel Mission in the 1770's. The clay reportedly came from Martin Ranch near the Mission (Dietrich, 1928, p. 131). Under the direction of the Mission Fathers, the Indians built a large kiln of adobe brick to fire brick tile, which was used to roof the church and cap some

of the walls (personal communication, Mr. Harry Downey, restorer of Carmel Mission, 1959). Commercially, tile was manufactured from clay obtained near Castroville by the Area Roofing Tile Plant (1924–1927), Salinas Valley Clay Products (1929–1931), and Castroville Clay Products (1931–1937 ?). Monterey Mission Tile Company near Seaside (1924–1928 ?) obtained black adobe from Thomas Field Ranch on the Laguna Seco Grant 5.5 miles east of the junction of State Highway 1 and the Salinas road. This clay, mixed with ground rejects from the kiln, produced very distinctive roof, floor, and step tiles when fired (Dietrich, 1928, p. 131).

Adobe

As mentioned above, adobe brick (blocks) was made beginning with the Mission period in the 1770's. The settlers in the Monterey-Carmel area later adopted the construction methods of the Missions, and adobe brick and tile manufacturing were probably the only significant mineral industries in Monterey County prior to 1850. The fondness of the local residents for adobe-type architecture still persists and many fine homes in this area are still being constructed of imported adobe brick.

The only commercial production of adobe brick during modern times was at Rancho Del Monte near the present airfield. Here, the subsoil of a Quaternary terrace deposit was used as raw material by the Carmel Building Specialties Company in the 1940's (Fiedler, 1944, p. 249). According to John B. Simpson of the Valley Rock and Adobe Company, present owner of the adobe deposit, Hans Sumpf manufactured bricks from the same deposit in the late 1940's and early 1950's. Mr. Simpson also made some adobe bricks in 1955 for experimental purposes. The soil developed on this terrace deposit is classified as Chualar sandy loam by the U. S. Department of Agriculture (Carpenter and Cosby, 1925, pp. 40–41, and map). The subsoil, which probably provided most of the raw material for adobe brick, is a clayey, silty sand. The subsoil extends to an average depth of 54 inches and is overlain by a thin soil layer. According to Carpenter and Cosby it averages 33 percent silt and clay, 58 percent sand and 9 percent fine gravel. As this type of raw material is widely distributed in the Carmel and Salinas Valleys and a steady market appears to exist for adobe brick in the Monterey Bay-Carmel Valley area, it might be possible to establish an adobe brick plant to supply the local needs. The present market is probably supplied by the Hans Sumpf Company of Fresno.

Fuller's Earth

J. C. Jens, under the name Mineral Earths Supply Company, is credited with producing 1,250 tons of fuller's earth in 1910 and 1912–1914 (unpublished Division of Mines records). At that time, the material was used for clarifying mineral oils and in "fulling" wool. The deposit has not been located and is not described in the literature. Jens also produced several thousand tons of pottery clay from a pit east of Chualar (Boalich, 1920, p. 65) but the exact location of this deposit and the nature of the clay are not known.

COAL

Coal was first discovered in Monterey County in 1870 and produced intermittently until 1935. Total production is probably in the order of 300,000 tons, most of which came from the Stone Canyon mine. The Stone Canyon deposit contains some of the highest rank coal in the state, that is considered to be a true bituminous coal by most investigators. Coal from the Carmel mine has been described as a lignite but the Priest Valley coal has not been classified as to grade.

Apparently, the coal deposits formed at somewhat different times in the geological past and are unrelated to each other. The Stone Canyon coal is found at the base of the Temblor Formation of early to middle Miocene age (Richardson and Wayland, 1963, p. 88). A few miles northwest, the Priest Valley coal is interbedded with rocks described as upper Miocene by Pack and English (1914, p. 159–160) but more recently shown to be middle or lower Pliocene (Jennings and Strand, 1958; based on unpublished data of T. W. Dibblee, Jr.). The Carmel coal deposit is part of a sequence of lower to middle Miocene nonmarine sediments that are considered to be equivalent to the Temblor Formation (Trask, 1926, p. 152–153).

Of the 3 coal deposits, only the Stone Canyon deposit is believed to have significant reserves. However, its remote location and poor competitive position with respect to other fuels in California make current exploitation unattractive. In addition, the coal is reported to have poor coking qualities (Jennings, 1957, p. 158), although unpublished data indicates the coking quality improves with depth.

Carmel (Carmelo) Mine. Location: E½ sec. 1, T. 17 S., R. 1 W., M.D., 5 miles south of Carmel on the north side of Malpaso Creek, reached from State Highway 1 over 2 miles of dirt road and trails. Ownership: Not determined.

The Carmel coal mine has never been completely described and many of the early reports and news articles in the Mining and Scientific Press and the Engineering and Mining Journal were fragmentary and vague. The following account is a summary of these old reports.

The coal seam of the Carmel Mine was discovered in 1874, and shortly thereafter the Monterey Coal Mining Company was organized to develop the deposit. During the next few years, a small production apparently was obtained and some of the coal was shipped to San Francisco. A railroad was constructed in 1879 to transport the coal 5 miles from the mine to the nearby coast for loading aboard ships (Irelan, 1888, p. 404). Mining ceased because of litigation and other reasons about 1880 and the mine was not reopened until about 1889. Development during 1889–

1890 consisted of cleaning out and re-timbering 720 feet of "tunnel" and sinking a 45 degree incline shaft to a depth of 95 feet, at the bottom of which a 100-foot drift was run to the north in a 6-foot-thick coal seam. A short distance south of the tunnel a double-compartment shaft was sunk to a depth of 275 feet and 3 coal seams dipping at 45 degrees were intersected below 255 feet (Angel, 1890, p. 347–348). In 1891 a hoisting works was completed. Presumably, some production followed before the mine fell idle about 1893. Total coal production by that time is reported to be 20,000 tons (Crawford, 1896, p. 54). In 1897, the Carmel Land and Coal Company reportedly gained control of the deposit and minor production is recorded for 1901. Nothing is known concerning the mine's development after that except in 1925 Laizure (1925, p. 30) reported that the mine had been idle for many years and A. M. Allen of Monterey was the owner at that time.

The geology of the deposit is not well known and there was some disagreement on the type of coal present and the thickness of the coal seams. P. D. Trask (1926, p. 152–153, Pl. 6) mapped and described the geology of the Point Sur quadrangle in which the deposit is situated. Trask states there are 4 thin beds of coal, all less than 3 feet thick, and these occur in the upper 150 feet of the formation, which was tentatively correlated with the Temblor Formation of Miocene age. The coal is lignite and development was in the lowest and thickest beds.

Priest Valley prospects. Location: Secs. 17 and 21, T. 20 S., R. 12 E., M.D., 19 miles east of San Lucas and 18 miles west of Coalinga. Ownership: Not determined.

Thin coal seams occur in carbonaceous shale beds and interbedded sandstone that are equivalent to the Etchegoin and Jacalitos Formations of early and middle Pliocene age. According to Pack and English (1941, p. 158 and Pl. V), the coal beds crop out as a southeasterly plunging syncline and extend from sec. 8, in Monterey County, to sec. 25, T. 20 S., R. 12 E., in Fresno County. The southeast extent in Fresno County was developed modestly in section 22 where it is known as the Drabble mine. The Monterey County portion of the deposit has also been prospected in secs. 17 and 21, but no production is recorded.

Other than some minor prospecting, the first development work was done about 1907 by the Monterey Coal Company (Pacific Coal and Clay Company) who dug a 60-foot slope (inclined shaft) and a 115-foot shaft with 75 feet of drifts at the bottom in the NE¼ sec. 21. Small pits were dug along the coal outcrop in sec. 17 by the same company. There has been little if any additional development in this area.

Stone Canyon Mine. Location: Sec. 14, T. 22 S., R. 13 E., M.D., 18 airline miles northeast of Bradley. Ownership: Dorothy M. White, Miami, Florida (Mrs. Hope S. Bagby, Hidden Valley Ranch, c/o San Miguel, owns the surface rights).

The Stone Canyon coal deposit contains some of the highest rank coal in California, the coal being classed as a high-volatile bituminous type (Cooper, et al, 1947, p. 36–37, 53 and Campbell, 1907, p. 435, 438). The deposit was discovered in April 1870 by F. M. Stone and has been developed intermittently, at times vigorously, until 1935, when the Stone Canyon Mine was last worked.

The coal seam is one of the thickest in California, being as much as 18 feet thick locally, but averaging about 12 feet. It apparently thins to 2 feet at the eastern extremity of the 300-foot level (T. O. Evans, personal communication to C. W. Jennings, 1955). Shumway (1928, p. 5–6) indicates the seam may be 10 feet thick at the western end and is "interrupted" due to faulting at the east end 300-foot level. There is no indication that the coal bed thins at depth within the mined area. The seam is divided locally into 3 parts by two impure beds, as much as 12 inches thick, that vary in composition from bone coal to clayey or sandy shale (Cooper, et al, 1947, p. 53). In some places one or both dividing layers are absent. Generally speaking, the coal bed strikes northwest and dips steeply near the No. 1 and No. 2 slopes. However, the attitude changes to an easterly strike and more gentle dips in the east and northeast part of the mine. The attitude is locally complicated by minor faults and rolls.

Overlying the coal seam is hard sandstone of the Temblor Formation (lower to middle Miocene) and locally underlying the coal is clay shale which probably is of the same formation (Richardson and Wayland, 1963, p. 88). This formation rests unconformably on the older Franciscan Formation and in turn is unconformably overlain by upper Miocene siliceous shales. The whole sequence has been folded into a northwest-trending syncline, the coal deposit being exposed on the southwest limb. The distribution, thickness, and depth of the coal seam under the syncline has not been determined by drilling; the coal is not known to crop out on the northeast flank of the syncline. Additional geologic data are given by Richardson and Wayland (1963, p. 88–91).

Records of the early development are vague and sketchy, but by 1875 four shafts reportedly had been sunk on the coal bed (Mining and Scientific Press, 1875, p. 2). Relations of these to later workings is not known. Probably the first reliable and reasonably detailed account of the mine development was given by W. A. Goodyear (1888, p. 172–173) after he examined the mine in 1887. At that time the coal seam was developed by 2 drift adits (No. 1 and No. 2 tunnels), 500 and 350 feet long, and a 90-foot inclined shaft. The portal of No. 1 tunnel lies just south of a sharp bend in Stone Creek (see Plate II). No. 2 tunnel, situated one-quarter mile to the southeast was driven N. 85° E. The 90-foot shaft was located about 1000′ feet downstream from the portal of No. 1 tunnel. By July 1888, the No. 1 tunnel had been extended in a southeasterly direction to a length of 1300 feet and 2 inclined shafts

—160 and 120 feet deep—were developed downstream in Stone Canyon. These shafts were located near and may be the same as the No. 1 and No. 2 slopes * (see map, Pl. II). According to Irelan (1888, p. 403–404) early shipments of coal were hauled by teams to San Miguel.

The mine lay idle from about 1889 to 1898, when the Stone Canyon Coal Company was formed. Subsequent development carried the No. 1 tunnel (also known as the "drift level") southeastward to a length of 3,000 feet (Campbell, 1907, p. 435–438). The No. 1 slope, which starts at the outcrop of the steeply-dipping coal seam, was driven 350 feet northeast down a 40° incline, and cross-cut back to the seam at the "300-foot level" where about 1,000 feet of drifts were driven northwest and southeast. Some of the coal produced prior to 1908 was sold, but most of it was used to run the mine or was stored.

In 1907, the property was sold and the Stone Canyon Consolidated Coal Company was formed, marking the beginning of the first major development of the deposit. A railroad over 20 miles long, a large tipple, 4,000 feet of gravity incline and a 2,000-foot tramway were constructed from the mine to the Southern Pacific Railroad at McKay Station, 3 miles north of San Miguel. Extensive construction of a mine plant and camp also was undertaken and by October 1908, when the first car of coal was shipped by rail, probably more than a million dollars had been spent by the Stone Canyon Consolidated Company (Shumway, 1928).[1] During the next year or so, the company extended the No. 1 tunnel southeast to its present termination. The 300-foot level, located just north of the No. 1 tunnel, also was extended to the southeast and more than 50 rooms were turned-off up dip (see Plate II). In addition, the No. 2 slope, started by the previous company, was extended 200 feet beyond the 300-foot level. Also, the No. 3 slope was begun, being driven from the 300-foot level about 150 feet down the gentle north dip of the coal seam. A series of disasters befell the operator during the development period: a mine explosion which killed 6 men in room 27 in January 1909, a flood which damaged the railroad bed in October 1909, and a mine fire in room 25 in January 1910, the latter closing the mine. In spite of all this, the company produced nearly 50,000 tons of coal in 1908–1909. Ownership of the property reverted to the Stone Canyon Coal Company, who reopened the mine in 1911 and produced modest amounts of coal until 1914 when a flood washed out the railroad bridge at the Salinas River. For the next 7 years, only enough coal was produced to keep the mine operating and dewatered.

As a result of financing by officials of the Inland Steel Company, the Stone Canyon Coal Company "reopened" the mine in the summer of 1921. During the ensuing year, the railroad bridge and mine plant were rehabilitated and about 50,000 tons of coal was produced (Jennings, 1957, p. 158). The company extended the No. 3 slope down the dip of the coal seam for 758 feet beyond the 300-foot level and opened 11 rooms on each side of the slope. They also extended the 300-foot level to a point 850 feet east of the No. 3 slope where the coal seam was disrupted by faults. Because the mine had been developed inefficiently, coal production could not be raised to a sufficient rate to realize a profit and the mine fell idle in mid-1922 (Laizure, 1923, p. 26–27). A skeleton crew kept the mine open until 1927, when it was allowed to fill with water.

The Stone Canyon mine was again reopened in 1930 by the Atlas Smelting, Mining and Refining Company. This concern extended the No. 1 slope to the "600-foot level," driving a drift southeast for about 1,000 feet at that level. About 10 rooms were opened along the drift and an estimated 10,000 tons of coal produced in 1931 (Jennings, 1957, p. 158).

Sometime in 1931, the mine was acquired by the American Coal Company which produced small amounts of coal in 1931 and 1932. Again the mine changed hands in 1932 and the California Coal and Coke Company (?) obtained minor production. The last known operator was the Monterey Coal Corporation which developed modest production from 1933 to 1935. According to H. S. Gale (unpublished notes), who visited the deposit in July 1933, the main development was carried on through the No. 1 slope, probably at the 600-foot level. The extent of this development is not known to this writer, but it is believed to be the last serious effort to develop the mine.

Altogether, since 1870 it is estimated that the Stone Canyon deposit has yielded about 250,000 tons of coal, much of which was used to operate the mine and mining camp. The rest was sold mainly for use as a domestic fuel in northern California. This is a rather small tonnage considering that upwards of $2,000,000 must have been spent by various companies in developing and operating the mine and railroad spur.

The quality of the coal has been determined by several investigators (Campbell, 1907, p. 435–438; Cooper, et al, 1947, p. 36–37; Shumway, 1928, p. 23). The coal is generally classed as high volatile bituminous having a heating value of 13,000–14,000 B.T.U.'s on an ash-free basis. It is generally low in moisture (4 to 8%), high in sulfur (4 to 5%), and yields 5 to 15% ash. A large amount of oil reportedly can be obtained by low temperature distillation (Shumway, 1928, p. 23). The coal is described as being hard and does not slack readily and some investigators consider it to be non-coking (Jennings, 1957, p. 158).

* A slope, as used in this report and in earlier reports, is an inclined passageway that provides access to or access within a coal seam. The No. 1 and 2 slopes are inclined shafts, No. 2 reportedly lying entirely within the coal seam. No. 3 slope is an inclined winze driven entirely within and down the dip of the coal seam. No. 2½ slope is an inclined winze, apparently sunk from the "sand rock" tunnel to intersect the coal seam.

[1] Many of the data presented for the years 1898 to 1928 has been taken from an unpublished report on the Stone Canyon coal mine by R. W. Shumway, Consulting Engineer. The report was courteously loaned to the writer by John F. Conway, 300 Montgomery Street, San Francisco.

However, coking tests may have been made on somewhat weathered coal from the 300-foot level and above. Coal from greater depths may have better coking properties.

The extent of the main workings of the Stone Canyon mine, as developed prior to March 1930, are shown on the mine map (Plate II). Since 1930, there has been some room and pillar development, probably at the 600-foot level, but the exact extent of these workings are not known to the writer. In 1960, all of the mine workings were inaccessible due to flooding or caving.

It is apparent that reserves developed above the 300-foot level are nil and some of the coal between the 300- and 600-foot levels has been mined. Reserves blocked out between the No. 2 and No. 3 slopes below the 300-foot level is estimated to be in the order of 700,000 tons, minus that which has been mined and that which is not recoverable. Substantial reserves may exist below the 600-foot level, but drilling has not been done to prove this.

COPPER

There are no known copper deposits in the county that have been developed commercially, but minor concentrations of copper minerals have been prospected in several areas. In general, the copper minerals appear to be confined to two geologic environments: 1) the Franciscan rocks and associated serpentine in the Los Burros district west of the Nacimiento fault and near Parkfield east of the San Andreas fault zone; and 2) at or near the intrusive contacts of crystalline limestone (Sur Series) and granodiorite in the Santa Lucia and Gabilan Ranges. The known occurrences of copper in each of the geologic environments are listed as follows:

Franciscan-serpentine environment:

1) Bedell prospect—oxidized copper minerals (copper carbonates) in serpentine (probably along fractures).
2) Hammond prospect—disseminated chalcopyrite ($CuFeS_2$) and pyrite (FeS_2) along shear zone in sandstone.
3) Lucky Moe mine—pyrite, chalcopyrite and native gold in calcite-quartz vein in sandstone.
4) Native Copper prospect—chalcocite (Cu_2S) with specks of native copper along shear zone in serpentine.
5) Unnamed occurrence on Table Mountain—foot wide vein containing chalcopyrite and possibly other sulfides cutting Franciscan rocks.

Crystalline limestone-granodiorite environment:

1) Chualar prospect—mineralized zone (mineralogy not known) in quartzite, granite and limestone.
2) Riley Ranch prospect—arsenopyrite, copper carbonates and magnetite in limestone near contact of igneous rock. An oxidized contact metamorphic zone (?).
3) Unnamed prospect near Trampa Canyon—chalcopyrite associated with pyrite in crystalline limestone near contact with quartz diorite.

Not much is known concerning the mineralogy or geology of the above named copper occurrences. Because of their non-commercial history, the deposits have not been investigated in any detail and most were not visited by the author. Apparently, all are small and/or low grade and the lack of economic development is not encouraging to future copper prospecting. However, small commercial deposits may exist, especially near contact metamorphic zones where acid intrusive rocks have invaded calcareous rocks. The calcareous rocks (limestone and dolomite) of the Sur Series are delineated on the geologic map and will provide a useful guide to prospecting for copper, as well as tungsten, molybdenum and other metallic minerals often deposited under similar conditions.

The reader is referred to the tabulated list at the end of this report for a little more information on the copper prospects.

DIATOMITE

All of the diatomite that has been mined commercially in Monterey County has come from the upper part of the Miocene Monterey Formation. This highly diatomaceous portion of the Monterey Formation is a recognizable stratigraphic unit in several parts of the county (Galliher, 1932, p. 22; Weidman, 1958, p. 93; Taliaferro, 1943, p. 459). On the south side of Hames Valley, the unit has been named the Buttle Diatomite Member of the Monterey Formation by Mandra (1963, p. 104–105). It is doubtful that these units are exactly equivalent (at least in age) to each other, but all occur near the top of the Monterey Formation and are considered to be late Miocene in age. Thinner and less pure diatomite beds occur in older parts of the Monterey Formation and in younger formations, such as the Santa Margarita, Pancho Rico and their equivalents of late Miocene and Pliocene age.

The relatively pure beds of diatomite of the upper part of the Monterey Formation occur west of the Salinas River and are best exposed in the vicinity of Hames Valley, Monterey, and King City. Other occurrences of potentially commercial diatomite may exist west of the Salinas River (e.g., near Pleyto), but none is known from the equivalent rocks east of that river. The most important deposits of diatomite in Monterey County, from a production standpoint, are located along the southwest and north sides of Hames Valley and 4 miles southeast of Monterey at the Work Ranch. A total of 47,906 tons of diatomite valued at $473,645 were produced from 1906 to 1942. No production has been recorded for this commodity either before or after that period.

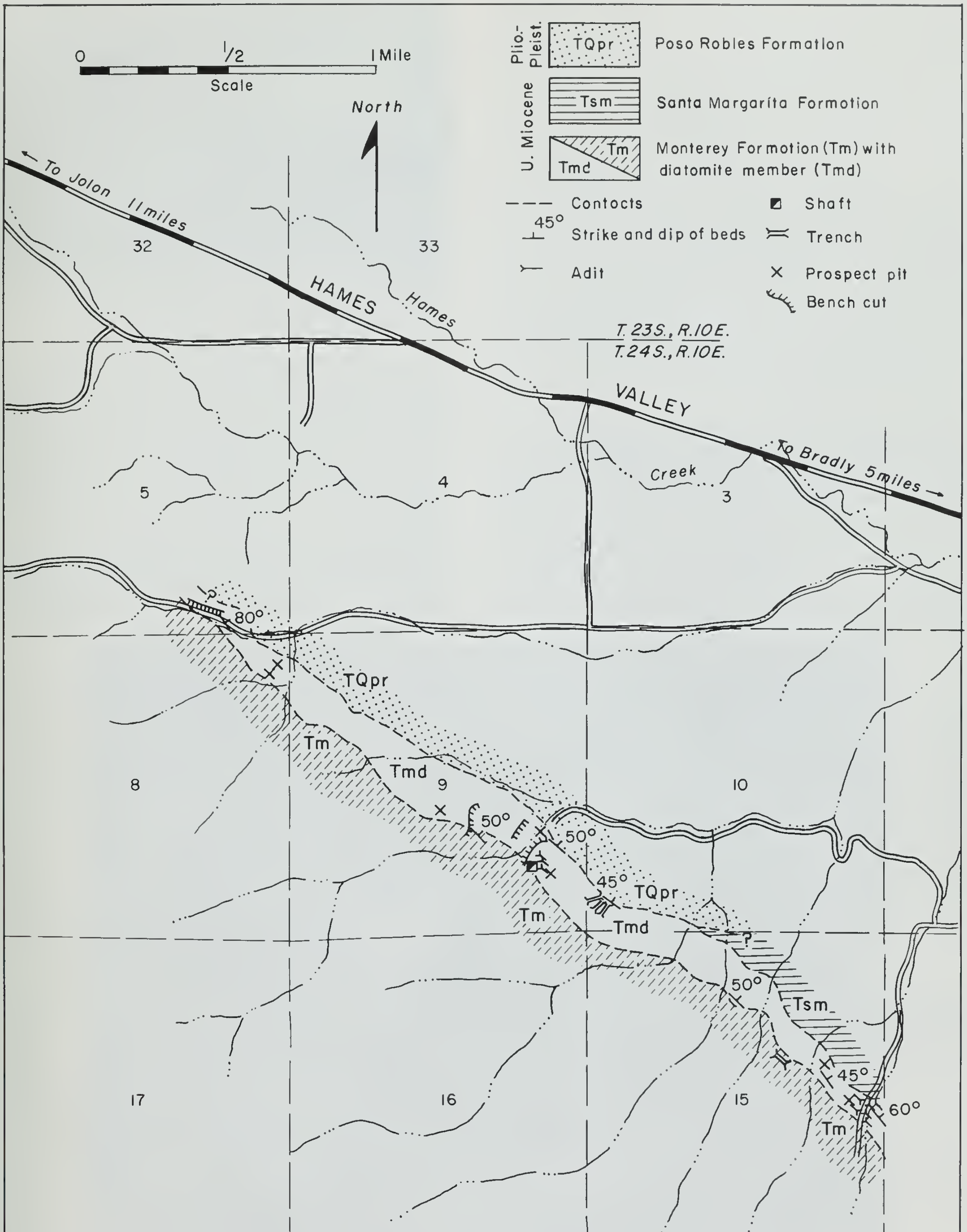

Figure 5. Geologic map of Hames Valley diatomite (geology mapped Jan. 18–20, 1960, by E. W. Hart).

It is not entirely known why diatomite mining ceased in Monterey County in 1942. Compared to the very large diatomite quarries operated by Johns-Manville Products Corporation and Great Lakes Carbon Corporation in Santa Barbara and Los Angeles (inactive since 1958) Counties, the smaller operators in Monterey County were at a distinct disadvantage because of their restricted marketing ability. Also, the deposits in Monterey County are somewhat smaller in size, and possibly less pure, and, because of moderately steeply dipping beds, the diatomite frequently had to be mined by underground methods to obtain selected grades of diatomite. The mining and marketing disadvantages still exist in Monterey County and it does not seem likely that a large diatomite operation can be initiated there until the present supply-demand relationship changes significantly.

Photo 16. View to north of hills lying north of Hames Valley. Gently rounded hills (plowed) are formed in diatomaceous rocks of the Monterey Formation. The underlying siliceous shales of the same formation are exposed in the higher background hills.

Geology of Hames Valley Diatomite

Diatomite of potential commercial importance occurs in a sequence of thick diatomaceous beds in the uppermost part of the Monterey Formation near Hames Valley. This sequence, known as the Buttle Diatomite Member, is underlain by and grades into siliceous shales and cherty beds of the Monterey Formation. Upper Miocene sands and pebbly sandstones of the Santa Margarita Formation locally, and possibly unconformably, overlie the diatomite sequence on both the north and south sides of Hames Valley. Middle and lower Pliocene sands and conglomerates unconformably overlie both the Monterey and Santa Margarita Formations on the north side of the valley. Non-marine clay, sand, and gravel of the Paso Robles Formation rest unconformably on both of these formations and in effect fill the synclinal trough of Hames Valley.

The diatomite member is exposed in two main areas: 1) a long belt paralleling the southwest side of the valley and 2) as gently dipping beds capping many of the low rolling hills in sec. 20, T. 23 S., R. 10 E.

Photo 17. Old adit at Riewerts deposit showing diatomite beds dipping about 45° N.E. Diatomite is nearly white, massive, and porous; it stands well in unsupported workings.

Photo 18. Thin chert interbeds are common in the basal part of the diatomite member which gradationally overlies the siliceous shale member of the Monterey Formation south of Hames Valley.

on the north side of Hames Valley. The geology of the main part of the belt on the southwest side of the valley, where most of the development and exploration has been conducted, is shown in Figure 5. The maximum thickness of the diatomite member is about 500 feet on the south, but the thickness could not be determined on the north side of the valley.

The diatomite sequence southwest of the valley was mapped as a northwest trending belt more than 3 miles long, but neither end of the belt was mapped (Figure 5). This belt probably is truncated by erosion and overlapped by younger formations in sec. 23, T. 24 S., R. 10 E., but reappears again to the south in sec. 26 (Mandra, 1963, p. 104). The northwest limit of the exposed diatomite appears to extend about 1½ miles beyond the mapped diatomite in Figure 5. At the northwest end of the belt, the diatomite apparently is overlain by gently dipping sediments of the Paso Robles Formation. In the area mapped, the diatomite beds dip 40° to 60° NE and strike N. 30–60° W., for the most part. The dip becomes nearly vertical and the strike N. 45° W. near SE cor. sec. 5. This sequence represents the southwest limb of the Hames Valley syncline and, therefore, probably is contiguous with the diatomite exposed on the north side of the syncline where the beds are gently folded.

The diatomite sequence mapped consists predominantly of diatomite beds that vary from nearly white to various shades of buff and light tan, and most have a pinkish cast. The buff and tan diatomite is believed to be more argillaceous than the white. Thin beds of bentonite or diatomaceous shale occur locally, and thinly bedded chert and siliceous shale are found near the bottom of the sequence. Diatomite beds in units to 7 or 8 feet thick have been observed in the Monterey siliceous shale conformably underlying the diatomite member. Lenticular and rounded concretions of chert as much as several feet in diameter also occur locally in the diatomite. Although exposures of diatomite are normally subdued and scattered, prospect cuts and tunnels indicate that the whitest and best commercial grades of diatomite southwest of the valley occur in the lower half of the sequence mapped there. The commercial grade and future value of the diatomite, however, can be determined only by extensive testing of the material for various uses. Disregarding grade, diatomite reserves in the belt several miles long on the south side of Hames Valley are very large. Reserves on the north side of the valley, because of poor exposures, cannot be estimated without drill or other exploratory data.

Ownership of the diatomite is multiple. Dicalite Division, Great Lakes Carbon Corp., 612 S. Flower St., Los Angeles 17, owns or controls the largest block of diatomite-bearing land extending from about the center of sec. 9 to the NW¼ sec. 23, and they have prospected much of the diatomaceous earth with numerous bench cuts, trenches and test quarries. Other important owners of diatomite along this belt are, from southeast to northwest: 1) Elmo Buttle; 2) G. A. Stonesifer; 3) B. Riewerts; 4) J. Riewerts; and 5) G. C. Saylor.

The diatomite in Hames Valley was mined almost continuously from 1906 to 1942. Commercial and exploratory operations include those of California Kieselguhr Co., Pacific Diatom Co., Great Lakes Carbon Corp., J. C. Jens, and B. J. Riewerts, as described briefly below.

California Kieselguhr Company. Location: E½ sec. 15, T. 24 S., R. 10 E., M.D., 4 miles west by southwest from Bradley. Ownership: G. A. Stonesifer (address unknown) and Dicalite Division, Great Lakes Carbon Corp., 612 S. Flower St., Los Angeles 17.

California Kieselguhr Co., Inc., opened this deposit in 1922 and completed a processing plant in San Miguel 14 miles away in December 1923. They worked the deposit by stoping in 7 drift adits as much as 150 feet long. Lower grade material was quarried in open cuts nearby. Mining operations were carried out in the canyon east of Buttle Canyon near the E¼ cor. sec. 15. The diatomite was trucked to San Miguel where it was milled, air classified, sacked, and shipped for use mainly in insulation, filtration, and dynamite (Laizure, 1925, p. 32–33, 36). The company apparently ceased operating in 1928, possibly because of a lease commitment to Pacific Diatom Products Company.

Pacific Diatom Products Company operated the same deposit from about 1927 to 1942. They erected a plant in Bradley or San Miguel at least as early as 1927 to process the diatomite, which was sold under the trade name of "Pacatome". Details of this operation are not known. Local residents state that the plant burned in 1930 or 1931, but was rebuilt shortly thereafter. The deposit has not been operated since 1942, but when visited in 1960 most of the underground workings were open. (For a general description of the diatomite sequence, of which this deposit is part, see "Geology of Hames Valley Diatomite" above.)

Great Lakes Carbon Corp. Location: Sec. 9, 10, 15, 23, T. 24 S., R. 10 E., M.D., 5 miles west of Bradley. Ownership: Dicalite Division, Great Lakes Car-

bon Corp., 612 S. Flower St., Los Angeles 17, owns major interest in the belt of diatomite extending from S½ sec. 9 to NW¼ sec. 23.

During the last 15 or 20 years, Great Lakes Carbon Corporation has acquired a major interest in the large belt of diatomite on the southwest side of Hames Valley. Their holdings include portions of the deposit developed previously by California Kieselguhr Co., Pacific Diatom Co., and B. J. Riewerts (which see). (The geology of the deposit is described above under "Geology of Hames Valley Diatomite".)

Although Great Lakes Carbon Corporation has not developed commercial production, in recent years they have made numerous prospect cuts, trenches and quarries in an effort to evaluate their holdings, as follows: 1) extensive stripping and several trenches on ridge just west of Buttle Canyon exposes the gradational contact between the lower portion of the diatomite sequence and upper part of the underlying siliceous shales; 2) small test quarries in E½ sec. 15 expose nearly white diatomite of the middle or lower part of the diatomite sequence; 3) SW cor. sec. 10 at top of hill—3 or 4 trenches cut transverse to the strike of the beds reveal the upper part of the diatomite member and unconformably overlying pebbly sandstone, the latter dipping 20° NE; 4) SE¼ sec. 9 east of creek—long bench cuts expose the entire sequence of diatomaceous strata; 5) SE¼ sec. 9 west of creek—benches 500 and 700 feet long expose a 300-foot thickness of the lower two-thirds of the diatomite member which shows a gradational relationship to underlying siliceous and cherty shale.

Riewerts deposit. Location: SE¼ sec. 9 (?), T. 24 S., R. 10 E., M.D. Ownership: Dicalite Division, Great Lakes Carbon Corp., 612 S. Flower St., Los Angeles 17 (diatomite rights only).

B. J. Riewerts produced small amounts of diatomite intermittently from 1906 to 1923 from the Hames Valley diatomite deposit. The exact location of his workings was not determined, but several drift adits, stopes, and a shaft develop the lower beds of diatomite in SE¼ sec. 9. The size of the workings suggest that more material was mined than is indicated by production records and it may be that other operators developed the underground workings. More recently, this section of diatomite has been exposed by several long bench cuts by Great Lakes Carbon Corp. (which see).

Other small quarries and pits to the northwest in secs. 5, 8, and 9 also may have been worked in the past by Riewerts or others. These workings include 1) two small quarries (NE¼ sec. 8) which appear to be little more than prospect pits; and 2) a long bench quarry (SE¼ sec. 5) from which several hundred tons of diatomite have been removed—reportedly for testing by Spreckels Sugar Co. Diatomite property in parts of secs. 5, 8, and 9 belong to B. J. Riewerts, R. B. Riewerts, et al., of Bradley.

Jens deposit. Location: SW¼ sec. 20, T. 23 S., R. 10 E., M.D., 6 airline miles northwest of Bradley. Ownership: Violet E. Alton, Pasadena.

This deposit is reported to have been developed as early as 1905 by the Mineral Earths Supply Company operated by J. C. Jens of Los Angeles. The diatomite was used mainly as "building blocks" for interior fire proof walls and substantial production was recorded from 1909 to 1921. There is no record of other development at this deposit.

Most if not all of the diatomite was mined by underground methods from a massive bed of diatomite 15 feet or more thick that strikes N. 20° E. and dips about 10° SE. The diatomite is nearly white in color, light weight, and composed almost entirely of diatoms, of which disc types predominate. The bed is part of a thicker sequence of diatomaceous rocks which cap several hills in sec. 20 and which generally appears to dip gently to the south. The diatomite sequence forms the upper part of the Miocene Monterey Formation which is locally overlain by the upper Miocene Santa Margarita Formation, marine Pliocene sediments and Plio-Pleistocene Paso Robles gravels to the south and east. Because of the scarcity of outcrops, the amount and quality of diatomite cannot be determined, but future exploration would seem to be warranted in this area as the diatomite appears to be similar and undoubtedly is equivalent to the thick sequence of diatomite exposed on the south side of Hames Valley. (see "Geology of Hames Valley Diatomite" above). According to Waring (1919, p. 598–599), bore holes show the diatomite to extend to an average depth of 240 feet, where it is underlain by black bituminous shale.

The Jens deposit is developed by 3 drift adits driven to the southwest, and a shallow quarry. The portals to all of the adits were open when visited in 1960. Two of the adits are 15 to 20 feet long, and the third adit (not entered) reportedly is 150 feet long. The longer adit is probably developed by additional rooms or stopes to account for the production. A small amount of diatomite also may have been obtained from a quarry about 300 yards to the southwest of the adits. Local residents state that the material from the quarry was too low-grade to be commercial. As a result of continued plowing, virtually all traces of the quarry have been removed.

King City diatomite. Location: Secs. 28, 33, and 34, T. 19 S., and secs. 13, 14, and 24, T. 20 S., R. 7 E., M.D., 3 miles west of King City. Ownership: Not determined.

Relatively pure beds of diatomite occur within a diatomite member of the Monterey Formation as mapped by R. M. Weidman (1958, unpublished, Plate 1A).[1] As shown in Figure 6, this member is a discontinuous stratigraphic unit exposed in two areas, each

[1] D. L. Durham (1963, p. 17–21 and Pl. 2) mapped these diatomite beds as part of an unnamed formation which is indicated to be early Pliocene in age.

about two miles long, and two miles apart. Separating the outcrop areas is a sandy unit which interfingers with the diatomite segments. Weidman (pp. 93–95, 202) describes the diatomite member in considerable detail as pure diatomite, silty diatomite, and sandy diatomite beds plus minor amounts of other sedimentary rocks. It has a maximum thickness of 250 feet just south of Branstetter Canyon. The average thickness of the southern segment is 85 feet and of the northern segment 110 feet. The strike is predominantly northwest and the dips moderate to the northeast.

Weidman states (p. 95) that the upper beds of the member generally consist of pure, low-density diatomite, where as the lower beds are less pure. As this deposit has had little or no development, future exploration probably is warranted in order to determine the commercial possibilities.

Work Ranch deposit. Location: NW¼ sec. 2, T. 16 S., R. 1 E., M.D., ½ mile by dirt road southweast of Salinas-Monterey Highway. Ownership: T. A. Work and/or Saucito Land Company (address not determined) own large acreage of grazing land (Saucito Rancho).

This deposit was worked by Monterey Products Company from about 1923 to 1931, when the processing plant burned down. The diatomite was quarried in benches and conveyed to the nearby plant where it was pulverized, air classified, and sacked. The product was sold under the trade name of "Calatom" and used as insulation, for filtration purposes in refining sugar, yeast, and oils, as a filler in dynamite and soap manufacture, and as an abrasive in polishes. C. McK Laizure (1925, pp. 33–35) has described the operation in detail. No significant development has taken place since that operation.

Diatomite of the Work Ranch deposit is part of the diatomite sequence that constitutes the uppermost member of the Monterey Formation and is late Miocene in age (O. E. Bowen, 1961, oral communication). The member dips gently to the north and is overlain unconformably by nearly horizontal sand and gravel beds of the Paso Robles Formation to the north and west. Soft, white, homogeneous beds of diatomite comprise the upper portion of the member which becomes cherty near the base and grades into porcellaneous shale of the Monterey Formation. Galliher (1932, p. 22) indicates a thickness of 500 to 800 feet for the diatomite member. At the main quarry, approximately 50 feet of thickness of massive white diatomite is exposed. The overlying diatomite is not well-exposed and its economic character was not determined. Buff-colored, argilaceous diatomite that is locally cherty is exposed in the lower part of the quarry. The extent and thickness of the white, uniform diatomite can only be determined by further prospecting.

Upper and lower benches have been developed in NW¼ sec. 2 by the Monterey Products Company. The upper bench is roughly 200 feet long, 100 feet deep, and has a maximum face of 35 feet. Most of the production apparently has come from this bench. The lower bench, which is about 300 feet long, 20 feet high, and of shallow depth, exposes the less pure portions of the diatomite deposit. The benches expose a section of diatomite about 150 feet thick, the lower two-thirds being relatively impure. Another quarry with a maximum face of 50 feet is located in SE¼ sec. 2 (O. E. Bowen, 1961, oral communication), but the diatomite here was not examined by this writer.

FELDSPAR

Feldspar is the general name given to a group of related silicate minerals that most commonly include orthoclase ($KAlSi_3O_8$), microcline ($KAlSi_3O_8$), and plagioclase ($(Na,Ca)Al(Si,Al)Si_2O_8$). Orthoclase and microcline are potash feldspars. Plagioclase, an isomorphous series of minerals ranging in composition from $NaAlSi_3O_8$ (albite) to $CaAl_2Si_2O_8$ (anorthite), is known collectively as soda-lime feldspar. As a group, feldspars are common rock-forming minerals found in most igneous and metamorphic rocks and the sedimentary rocks derived from them. In commercial usage, the term "feldspar" includes feldspar-quartz mixtures containing as much as 25 percent quartz. The quartz in such mixtures generally is regarded as a diluent rather than an impurity (Wright, 1957, pp. 195, 198).

High-grade potash feldspar is generally mined from coarsely-crystalline pegmatite dikes and processed by hand sorting. Lower grade potash feldspar and mixtures of potash feldspar and soda-lime feldspar are obtained from feldspathic sands, aplite dikes and feldspar rich granitic rocks, which are usually beneficiated by flotation.

Only one pegmatite dike, the Jens deposit, has been mined for potash feldspar in Monterey County. This deposit has been inactive since 1920, but it has yielded more than 6,000 long tons of feldspar. Since 1952, Del Monte Properties Company has produced a mixed, potash and soda-lime feldspar concentrate which is separated from feldspathic dune sand by flotation methods. From 1952 to 1961, much more than 100,000 tons of "flotation" feldspar has been produced by Del Monte.

The U. S. Bureau of Mines lists feldspar production in California at 76,010 long tons valued at $885,992 for 1960. A substantial part of this production includes potash feldspar mined in San Bernardino County as well as flotation feldspar processed by Del Monte Properties Company. However, probably more than half of the feldspar production credited to California consists of feldspar not actually separated from the quartz in dune sand. Such "feldspar" is produced near Pacific Grove by Owens-Illinois and Del Monte Properties Company as a source of glass and specialty sand

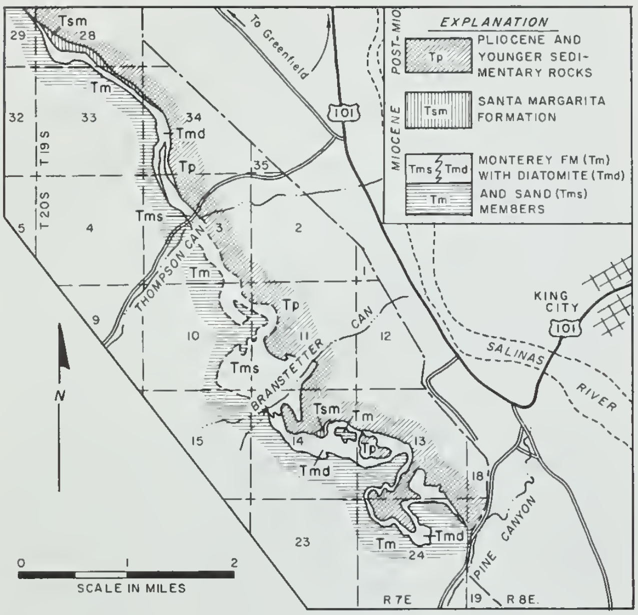

Figure 6. Geologic map showing diatomite west of King City (data after R. M. Weidman, 1958, pl. 1A).

and is treated more fully under the Sand and Gravel section.

Del Monte Properties Company has produced feldspar from feldspathic dune sand since January 1952, when they installed flotation cells at their sand plant near Pacific Grove (see Del Monte Properties Company under Sand and Gravel for detailed description of deposit and plant). The dune sand is composed of about 51 percent potash and soda-lime feldspars, the balance being quartz and a minor amount of biotite and heavy minerals. After the biotite and heavy minerals are removed by flotation, some of the sand is separated into quartz and feldspar fractions by additional flotation. Although the quartz fraction is relatively pure (98 to 99 percent SiO_2), the feldspar fraction contains only 75 to 80% feldspar. According to P. C. Valentine of Del Monte Properties Company (personal communication, July 18, 1961), chemical analyses show that the unground feldspar product contains about 17% Al_2O_3, 70% SiO_2, 5% Na_2O, 4¼% K_2O, 2½% CaO, and 0.10-0.15% iron oxides. From this, it can be determined that approximately 80% is feldspar and 20% is quartz. The feldspar consists of about 2 parts soda-lime feldspar (probably oligoclase-andesine) to one part potash feldspar.

Because the feldspar product contains a substantial amount of soda and a large percentage of quartz, it cannot compete with high-grade potash feldspar utilized in many pottery and enamel uses. According to Del Monte Properties Company, half of the feldspar sold is ground for use in porcelain and certain ceramic products, mainly in the Los Angeles area. The unground feldspar is sold to glass manufacturers in the San Francisco and Los Angeles areas. In the past, the company apparently was unable to sell all of its feldspar product and a large open stockpile existed at their sand plant when it was visited in July 1959. However, in November 1962, the company reported that this situation had changed and feldspar demand then exceeded feldspar production at their plant.

Jens deposit. Location: NW¼ sec. 34, T. 15 S., R. 5 E., M.D., 9 miles by road east of Chualar, via Muddy Creek (dirt road) and an old wagon trail. Ownership: Stauffer Chemical Company, 420 Montgomery Street, San Francisco.

This deposit was first developed about 1907 by J. C. Jens of Los Angeles, who operated it (partly under the name Mineral Earths Supply Co.) almost continuously until 1919 or 1920. Boalich (1921, p. 156) states that George W. Elder of San Francisco operated a portion of this deposit in 1920. According to Waring and Bradley (1919, p. 601), feldspar was produced and marketed since 1907, but production has been recorded only since 1909. A total of 6,250 tons of material have been produced, most of which was shipped to pottery makers. Since 1920, the deposit has been inactive.

The feldspar is found as granite pegmatite and associated aplite and leucogranite dikes that are intrusive into granitic country rock. The size of the pegmatite body is not known, but outcrops of pegmatite have been traced an estimated one-quarter mile east of the quarry and a short distance west. Scattered outcrops of pegmatite occur elsewhere in the vicinity to the northwest and it is not known whether the main group of croppings represent a large pegmatite dike or several smaller ones. At the quarry site, creamy-white feldspar occurs as coarsely crystalline masses of microcline (potash feldspar) containing only a small amount of intergrown quartz and local biotite in deformed masses as much as 4 feet across. Elsewhere, the quartz content increases, forming graphic intergrowths, and books of biotite are found. Quartz also occurs as veins as much as one foot thick. The feldspar, which is slightly weathered and locally iron-stained, comprises an estimated two-thirds of the deposit at the quarry. An analysis of the feldspar by E. W. Rice (Waring and Bradley, 1919, p. 602) showed SiO_2—65.66%; Fe_2O_3—0.40%; Al_2O_3—21.34%; CaO—1.50%; K_2O—11.85%; loss—0.48%. Although soda (Na_2O) was not reported on, the high alumina and lime percentages indicate a significant amount of plagioclase is present with the potash feldspar.

The Jens deposit is developed by two hillside quarries on the east side of a ravine. The lower quarry exposes the best quality feldspar at the deposit and probably accounts for most of the production. It consists of a narrow cut about 150 feet long with a maximum face of about 40 feet. The adjacent upper quarry is shallower and smaller, exposing light colored

granitic rock (leucogranite) for the most part. It does not appear likely that this deposit will be developed further because 1) hand-cobbing would not result in a consistently high-grade potash feldspar product; 2) a relatively pure feldspar product could be obtained only through expensive grinding and flotation; and 3) the present feldspar markets in California are supplied mostly by flotation feldspar from dune sand near Pacific Grove and by high-grade pegmatite feldspar from out of state.

GEM STONES

Semiprecious gem stones have been gathered in Monterey County for many years by mineral dealers, amateur collectors, and lapidarists, but there has been no formal mining of these materials. Most of the gem stones so obtained are sold rough, slabbed, or as finished jewelry and art work. However, only a small portion of the gem stones sold are believed to be reported on official records. The recorded (intermittent from 1935 to 1963) production of unprocessed nephrite jade and jasper, plus small amounts of rhodonite and other minerals, amounts to 7,168 pounds valued at $3,883.

Nephrite Jade

Nephrite jade is a compact, fibrous form of tremolite or actinolite and is similar in appearance to jadeite. It is found in place at Jade Cove (W½ sec. 19, T. 23 S., R. 5 E.) just south of Plaskett Creek and at Cape San Martin (NE¼ sec. 31, T. 23 S., R. 5 E.) just south of the Willow Creek bridge. Here the jade is exposed as pods and nodules in cataclastic schist and mylonite, probably derived from Franciscan sedimentary rocks and the intruded serpentine. R. A. Crippen, Jr. (1951, pp. 3–14), who has described these deposits in great detail, points out that the exposures of nephrite "are excellent for geologic observation, but the material found in place is not of choice color."

The Jade Cove jade was the first discovery of nephrite jade in place in California. Jade pebbles and boulders have been found along the beaches in southern Monterey County, especially near Jade Cove and Cape San Martin, and have provided excellent museum specimens and fine quality lapidary material for more than 20 years. These jade localities are well known among the numerous mineral dealers and mineral and lapidary societies, and constant collecting over the years has left the beaches practically free of jade. However, small quantities of jade pebbles are exposed on the beaches after storms.

In addition to the beaches and cliffs, nephrite jade also has been found offshore in the Cape San Martin-Jade Cove areas by skin divers. Individual boulders weighing as much as 100 pounds or more have been obtained from the sea floor as early as 1955–1956 by divers using self-contained underwater breathing apparatus. Prior to May 1957 (Mohler 1957, p. 4–5) nearly 1,000 pounds of jade had been recovered by this method.

Unpublished data show that recorded production of jade through 1960 amounts to more than 1,000 pounds and is valued at nearly $2,000. However, the actual amount of jade collected undoubtedly is many times this amount, although not all is of gem quality.

Jasper

Jasper is a cryptocrystalline variety of quartz that is generally opaque. The inclusion of finely divided iron oxides usually give the jasper its characteristic colors, which may be solid or variegated. Jasper is commonly found as pebbles, in streams or along the beach; outcrops are much less abundant. One of the most notable deposits of in-place jasper in California is located in Stone Canyon, 16 miles northeast of Bradley. Here, the jasper is brecciated and cemented with chalcedony. Other occurrences of similar material have been noted on Mustang Ridge along State Highway 198 near the western margin of the San Andreas fault zone. The recorded production of jasper to 1960 is 3,775 pounds, valued at nearly $1,000, most of which probably came from the Stone Canyon deposit. It is likely that more jasper has been collected in Monterey County than records indicate.

Stone Canyon deposit. Location: Probably SW¼ sec. 16, T. 22 S., R. 13 E., M.D., near the confluence of Stone Canyon and Nelson Creek. Ownership: Mrs. Hope Bagby, Hidden Valley Ranch, San Miguel.

This deposit has been known and developed as a collecting site at least as early as 1892 when the first of several specimens of Stone Canyon jasper was donated to the California Mining Bureau (now Division of Mines and Geology) for exhibit. The deposit consists of a "vein" 2 to 4 feet thick of distinctive, brecciated jasper cemented with chalcedony (Rowe, 1956, pp. 44, 46). The origin of this material is not definitely known, but probably it formed as a result of brecciation of Franciscan chert and later cementation by secondary chalcedony. According to Sperisen (1938, p. 49), "the deposit contains several thousand tons of jasper, including boulders weighing as much as several tons each. The dominant color of the jasper here is tan and brown and the breccia is cemented with chalcedony varying in color from white, through blue, purple, brown, and black." The material is said to be easy to work and takes a high polish.

Little if any formal development has taken place and, in all probability, a substantial amount of material remains at the deposit. However, the deposit is on private property and is not open to individual prospectors or collectors.

Rhodonite

Rhodonite is a pink manganese silicate generally associated with black manganese oxides or pink carbonate. It is similar in color to rhodochrosite (manganese carbonate), but is harder, being about 6 on

Mohs' scale of hardness. When relatively pure or when mottled with black oxides, rhodonite is prized as a lapidary material. The only gem-quality rhodonite known in Monterey County was found as boulders near the mouth of Limekiln Creek, in sec. 22, T. 22 S., R. 4 E. (R. A. Crippen, personal communication, 1960). It is said to be found in place at the north bridge abutment in Limekiln Creek, but the deposit is now either destroyed or covered due to recent bridge construction. The rhodonite probably formed by local metamorphism of manganiferous chert in the Franciscan Formation.

GOLD

Gold is one of the first minerals to be mined and prospected in Monterey County. The desire to find gold in the county at an early date was stimulated by spectacular successes in the Sierra Nevada and elsewhere. J. B. Trask (1854, p. 58) reported that placer gold was known to exist around the Jolon area as early as 1850 and miners were working the placers in that area in the early 1850's. The occurrence and mining of gold was also mentioned by Trask in the vicinity of Rancho Tularcitos on the upper Carmel River; "on the Francisquito", a southwest tributary of the Carmel River and on the tributaries near the headwaters of that river. In addition to placer gold, Trask mentioned that auriferous "talcose and chlorite slate" in the Santa Lucia Range were mined "to a considerable extent" during the summer of 1853.

J. D. Whitney (1865, p. 158), who made a survey between 1860 and 1864 for the State of California, reported that gold was found in various places in the Santa Lucia Range, but nowhere in large quantities.

Gold and quicksilver prospecting had become so popular in the Santa Lucia Range in southwestern Monterey County, that the Los Burros mining district was organized at a miners' meeting held on February 5, 1875. At that meeting, H. C. Dodge was elected Chairman, A. C. Frazier, Secretary, and William T. Cruikshank, Recorder; and the boundaries of the Los Burros district were defined as follows: ". . . commencing at the mouth of the San Kapoho [San Carpojo Creek] following Pacific Ocean northerly to Prewitt's trail, thence following said trail to McKerns, thence following the Nacimiento [River] to the mouth of the Los Burros Creek, thence to the place of the beginning." [1] During the first 12 years of recording, 131 mining claims were located in the district. Although most of the claims were located on quicksilver leads, some minor success was gained in gold placering. It was not until April 7, 1887 that W. D. Cruikshank, the Recorder's son, discovered a small quartz vein containing free gold. This he named the "Last Chance", which is now part of the Buclimo mine. This "strike" triggered an avalanche of mining claims, in the following months. Between April 1887 and August 1888 about 215 locations were made in the Los Burros district and 216 more were made from August 1888 to April 1891. Records of claims filed between 1891 and 1900 are missing, but it is believed that the rate of locating dropped off due to lack of success in lode gold mining. However, placer discoveries along the various forks of Willow Creek (includes "Spruce" and "Dogvine" Creeks) at the turn of the century stimulated another rash of prospecting and from August 1900 to January 1909, 322 mining claims were made. It is estimated that a total of 2,000 or more claims have been staked in this mining district, most within 3 miles of the Last Chance mine. The great majority of these were gold claims.

In spite of the large amount of prospecting in the Los Burros district, gold production has been minor. The U. S. Bureau of Mines records, which only date back to 1889, show a total of 4,599 ounces of gold and 494 ounces of silver, worth \$104,471 and \$305, respectively. Waring and Bradley (1919) show \$40,000 worth of gold produced from 1889 to 1901. Inasmuch as gold production for 1887–1888 as well as other unrecorded production (e.g. sniping or high-grading) is believed to be substantial, the total production for the Los Burros district is estimated to be in the order of \$150,000. Of this total the Last Chance produced an estimated \$62,000. An equivalent amount of production was accounted for collectively by the Plaskett group (lode), Spruce Creek placer (Ralston), Grizzly (lode), New York (lode) and Plaskett placer.

The peak of activity in the Los Burros area came from 1887 to 1892 when the town of Manchester (also called Mansfield) flourished. This town, which was located just south of the Last Chance mine in the NE¼ sec. 2, T. 23 S., R. 5 E., had a population of 125–150, a post office, two general stores, a restaurant, several saloons and a dance hall. Manchester burned down in 1892 and little evidence of that town remains today.

Geologically, the Los Burros district is underlain by typical Franciscan sandstone, chert, shale, serpentine, and volcanic rocks of Late Jurassic to Cretaceous age. These rocks have been strongly faulted, crushed and sheared, and locally metamorphosed. The sandstone, locally, has been rendered somewhat "slaty" as a result of shearing, and quartz has been deposited as veins along the shear and fracture planes. Some quartz veins also have formed in the other Franciscan rocks and serpentine, but most of the gold-bearing quartz is associated with fault gouge in sandstone. Repeated fault movement during quartz mineralization has resulted in ribbon structures and small discontinuous veins.

Although the gross structure (major faults and rock contacts) of the district trends predominantly northwest, the principal trend of quartz veining in the Gold Ridge-Buclimo area (south side of Willow Creek) appears to be roughly east-west, and most of the gold-bearing veins trend within 30 degrees of east-west. However, most local structures and quartz veins north of Willow Creek trend north or northwest.

[1] From Book A of the Los Burros Mining District Recorder; this is part of the district's records now on deposit with the County Recorder at Salinas.

Placer gold has accounted for ¼ to ½ of the county's gold production and for the most part is concentrated as coarse, ragged fragments in recent stream gravels of Willow Creek and its tributaries. Stream gravels of Plaskett, Alder, Salmon and other creeks that drain the lode gold areas have also been worked, but with only minor production. In addition to stream gravels, local river and marine terrace gravels and soil debris have been hydraulicked and sluiced in the same vicinity with unknown, but probably minor, success.

Free-milling gold has been the most important type of lode-gold obtained in the area. Free gold occurs with iron oxide and pyrite in white vein quartz or associated fault gouge in the oxidized (above the water table) zone. Below the water table, the gold is associated with pyrite and arsenopyrite in finely divided form and is difficult to win without cyanidation and other processing. At several mines, finely-divided gold is associated with pyrite and chalcopyrite in a calcite-quartz gangue.

Because of the rugged topography and high water tables, zones of oxidation tend to be shallow or nonexistent, except locally along fracture zones where permeability is high. Most of the mineable ores occur in the oxidized parts of these zones as small, high-grade shoots or lenses. Some of the high-grade ore shoots are believed to develop along fracture zones at the intersections of subsidiary fractures. Between the shoots, the ore is generally too low in grade to be worked profitably. As the veins are small and the primary ore is of low grade, it is apparent that large bodies of mineable ore, free milling or otherwise, cannot be expected to occur in the district. J. M. Hill (1923, p. 329) expressed this general conclusion, stating that "mineralization of the district is not particularly strong, and, although there may be further discoveries, near the surface, of pockets containing free gold, it is believed that all that can be expected below relatively shallow depths will be rather small bodies of pyritic ores of relatively low tenor".

Other areas or districts in which gold is found in Monterey County are river gravels around Jolon, the tributaries and upper drainage system of Carmel River, and Cholame Valley near Parkfield. Angel (1890, p. 345) stated that "Gold has been mined from the placers on the San Antonio and also on the Big Sandy, a creek in the Mount Diablo Range, near Slack's Canon". Gold also has been reported from the stream gravels in Miner's Gulch, a tributary to Chalone Creek. A number of small prospects have been opened along Miner's Gulch, mostly in sec. 33, T. 17 S., R. 7 E., but nothing of importance has been found (Andrews, 1936, p. 33, map).

Jolon Area. The Jolon area was one of the first to be prospected for gold in the county and yielded placer gold as early as 1850 (Trask, J. B., 1854, p. 58). Haley (1923, p. 153) mentioned that large nuggets of gold were obtained from the placer deposits west of Jolon. However, he states that apparently no substantial amount of placer ground exists which would justify development other than by pick-and-shovel methods. Weidmen (1958, p. 202) states "local people report minor production of placer gold in the early days from Mission Creek and Ruby Canyon. In the Mission Creek drainage, gold could have been washed down directly from a source in granitic bedrock; in Ruby Canyon gold has apparently been reworked from undifferentiated marine Pliocene-Paso Robles Formation". The only mining operation of record known to this writer is the Ruby Placer mine which was worked in 1914 (Waring and Bradley, 1919, p. 606). Located in Old Man Canyon, a tributary to Ruby Canyon, this claim was never worked commercially, although some gold was obtained in prospecting (see Ruby placer in tabulated list). Irelan (1888, p. 405) sheds a little more light on early placer gold mining near Jolon in the following paragraphs:

". . . Placer mining was carried on intermittently for several years. At one time over one hundred Chinese were engaged in gold washing in the vicinity of Jolon, it being supposed that the land in that neighborhood was Government territory. It proved, however, to belong to the Milpitas Grant, and the owners compelled the Chinamen to discontinue their work. Gold washing was afterwards carried on further west, in the ravine and gulches of the Santa Lucia Range. The gold was principally coarse gold nuggets, some of the value of $5 being occasionally found.

"From the desultory character of the workings, it is naturally difficult to form any estimate of the amount of gold that has been obtained in this district; but in 1877 and 1878 Messrs. Dutton and Tidball, who owned a store at Jolon, took in $2,500 in gold dust from the Chinamen".

Carmel River. The existence and mining of placer gold in the Carmel River and its tributaries is mentioned by Trask (1854, p. 58) and is briefly described above. The source of this gold was probably the Santa Lucia Quartz Diorite and Sur Series metamorphic rocks within the Carmel River drainage system. However, no specific lode gold deposits are known to the author in that drainage area.

Cholame Valley Area. Irelan (1888, p. 405) reported that "ledges of auriferous quartz are said to have been found in the Cholame Valley". Waring and Bradley (1919, p. 606) stated "On the Cholame Grant, 7 miles southeast of Parkfield, there is a series of gulches with gravel deposits which have yielded some placer gold. L. Patriquin of Parkfield has a lease from R. E. Jack, owner". However, there is no recorded production from this area, which is locally known as Gold Hill. Howard Jack, present owner of the Cholame (Jack) Ranch, showed this writer nuggets of gold as much as ⅜-inch across which he states came from the gulches along the western slope of Gold Hill.

Ancona (Brewery) mine. Location: SE¼ sec. 34, T. 23 S., R. 5 E., M.D., on Willow Creek (Gold Ridge) road, 3 miles east of Cape San Martin. It adjoins the Melville Consolidated Mines group of claims to the east. Ownership: Art Sherman and Archie Hammond, 1015 Shell, Pacific Grove, own one unpatented lode claim.

The Brewery claim was first located August 25, 1887, according to the old Los Burros mining district records now on file with the Monterey County Recorder. The early history of this mine is vague but Irelan (1888, p. 409) reported that a 3-foot wide ledge, striking northeast, was being worked through two tunnels totalling 150 feet in length. U.S. Bureau of Mines records indicate no production since 1902, but gold may have been produced prior to that date. In 1916, W. W. Pugh apparently relocated the claim as the Ancona and about 1923 S. D. Pugh was reported to be the owner (Laizure, 1925, p. 38). Sherman and Hammond apparently acquired the mine some time since 1940, and in 1958 leased it to Gerald Doyle, Watsonville, and James Pauley, Big Sur. Doyle and Pauley reopened the caved workings and prospected an ore zone which they reported ran as high as $2,690 per ton for a selected sample. Although the high assay caused a minor sensation locally, subsequent milling, concentration and amalgamation of a 5-ton ore sample resulted in a gold recovery of only $20 per ton, which proved unprofitable (G. A. Doyle, 1963, personal communication). Doyle and Pauley abandoned the lease in early 1959.

Doyle stated that the vein averaged about 3 feet thick and consisted of several veinlets of quartz interleaved with fault gouge in sandstone. This vein has a northeast strike and is nearly vertical where intersected by the main adit. Mineralization consists of finely-divided free gold distributed along fractures in quartz and black gouge. Associated minerals are pyrite, chalcopyrite, and arsenopyrite (?) with secondary calcite along the fractures. High-grade ore apparently is concentrated in very small shoots.

Prior to the recent development, the main workings reportedly consisted of an adit driven 97 feet to the east where it intersects the northeast trending vein. At this intersection are short drifts to the northeast (caved) and southwest (backfilled). A short crosscut run 36 feet to the south from the adit intersects the vein, which was drifted for 10 feet to the east and west. Near the end of the adit, a 38-foot shaft and a 21-foot winze, both caved, were developed on the vein. Doyle and Pauley reopened the shaft and winze and extended the drift in the crosscut 20 feet to the east. This drift uncovered the recently-tested, high-grade ore.

Buclimo (Last Chance, Cruikshank). Location: Secs. 34 and 35, T. 23 S., and secs. 1 and 2, T. 24 S., R. 5 E., M. D., 7 miles by road east of State Highway 1. Ownership: Buclimo Mining Company, c/o Rudolph Ernst, President, 1361- 7th Ave., San Francisco, owns the patented Last Chance, Pansy, Pine, Mary S., Mary S. Extension, West Extension No. 1 and East Extension No. 1 lode claims and the unpatented Ora F No. 2 and Perry lode claims totalling about 150 acres.

The Last Chance (Buclimo) lode was discovered in 1887 when W. D. Cruikshank uncovered a "blind lead" containing free gold. This was the first important gold discovery in Monterey County and it is described in detail by Irelan (1888, p. 405–407). Cruikshank worked the mine for 2½ years, and reportedly drove 900 feet of workings, recovering $22,000 to $23,000 in free gold from 375 to 400 tons of ore (Dockweiler and Gilman, 1910, unpublished report for Buclimo Mining Compay). In August 1889, the mine was sold to a company headed by T. A. Bell, who sunk a shaft to 140 or 150 feet, extended the drifts at the 97-foot level, and stoped the ore above the 97-foot level. Bell died about 1892 after obtaining an estimated $18,000 worth of gold from free-milling ore. The ore was processed using a 5-foot Huntington mill, a concentrator, and a series of sluice pans. Between 1892 and 1901, Cruikshank and J. M. Krenkel leased the mine and worked out the remaining ore above the 97-foot level. It is reported that during this interval they obtained $13,000 to $14,000 in gold from ore that assayed $40 to $50 per ton. For several years after that, the mine lay idle due to litigation.

In 1908, the Last Chance mine was sold to the Buclimo Mining Company, the name *Buclimo* being derived from the names of stockholders Burnham, Clinton, and Mory. The new company spent a considerable sum of money developing the mine during the next few years; they sunk a shaft to 241 feet, drove 326 feet of drifts at the 197-foot level, reopened the caved drifts at the 97-foot level, and began a long drain tunnel. In spite of the extensive development, records show only $200 worth of gold produced (in 1909) and it is apparent that most of the development effort was in digging an 1,800-foot drain tunnel which reached to within 300 feet of the shaft in July 1916 (Waring and Bradley, 1919, p. 603–604). The drain tunnel, started near the incline of the old Grizzly mine to the east, was intended to intersect the Last Chance vein at a depth of about 400 feet. However, the tunnel was never completed and the last work done on it is believed to have been done about 1920.

Little or no work was done on the mine thereafter until 1937 when Frank H. Jerdone leased the property and produced 10 ounces of gold and 2 ounces of silver from sulfide ore. A lease to Charles J. Wonder of Los Angeles during the next 4 years resulted in the production of 212 ounces of gold and 178 ounces of silver. As most of the ore was of a sulfide type, production probably came from below the 97-foot level. U.S. Bureau of Mines records show that nearly all of the ore was concentrated and shipped to Selby for refin-

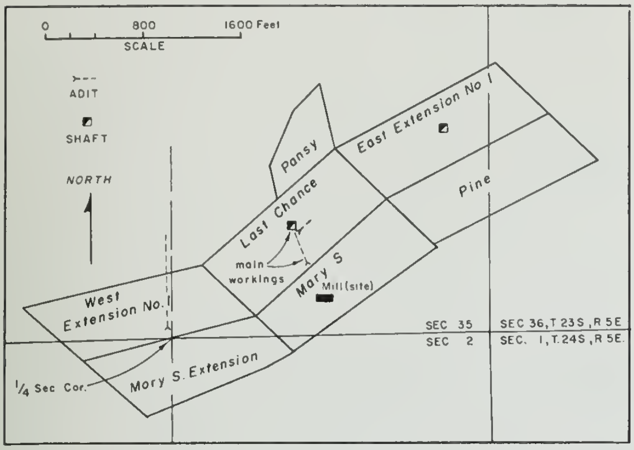

Figure 7. Map of patented claims of the Buclima mine showing location of adits and shafts (data after plat surveyed 1911).

ing. From 1938 to 1941, \$7,390 worth of gold and silver was recorded from 452 tons of ore, which is an average of \$16.35 per ton of ore. The Last Chance mine has been idle since 1941. Total gold production from 1887 to 1941 is estimated to be about \$62,000, most of which was obtained from free-milling, oxidized ore.

Aside from the Last Chance claim, the other 6 patented claims of the Buclimo have no record of production, although several show development workings on the patent plat (patented February 25, 1915). In addition to the patented claims, the Buclimo Mining Company owned a number of adjacent unpatented claims to the east and south, including the Perry, Ora F Nos. 1 and 2, Rankin, Gold Gulch Nos. 2, 4 and 5, Good Gold, Flatview, and Lucky Jim. Of these, only the Perry and Ora F No. 2 are still held and these are no longer contiguous with the patented group. Neither the Ora F No. 2 nor the Perry were productive under the present owner, but the Ora F No. 2 had some production in 1890 and 1902–1904 when it was known as the Grizzly (which see).

(Most of the following data regarding the geology, mineralization and workings of the Last Chance mine are taken from an unpublished mine report by J. H. Dockweiler and C. F. Gilman (1910). This report conflicts in many ways with published reports (e.g. Irelan, 1888, p. 405; Preston, 1893, p. 260; Davis, 1912, p. 697; Waring and Bradley, 1919, p. 603; Hill, 1923, p. 327; Laizure, 1925, p. 38; and Franke, 1935, p. 463), which also conflict with each other. However, the consulting report by Dockweiler and Gilman is believed to be the result of the only detailed study made of the Last Chance mine and therefore should be the most authoritative.)

There are 4 or 5 quartz veins at the Last Chance mine and at least two of these have been worked for gold. These veins generally strike northeast and dip from 38° NW to vertical, although one reportedly dips to the south. The veins cut massive Franciscan sandstone that is locally fine-grained and slaty. A narrow, northwest-trending body of serpentine has intruded the sandstone in the north part of the Last Chance claim. The important veins, which are confined to small faults or shear zones in the sandstone, consist of one to three stringers of quartz intercalated with fault gouge. Most of the ore has been mined from a vein which strikes N. 60° to 70° E. and dips steeply northwest. It varies from 3 feet to more than 7 feet thick, including an aggregate thickness of quartz of 6 inches to 7 feet. Although the quartz stringers pinch and swell rapidly, an estimated average thickness for the quartz would be about 1½ feet. The other mineralized veins average less than one foot of quartz thickness. All of the quartz veins are considerably fractured and sheared and thus are intermixed with fault gouge. Mineralization is confined principally to the quartz and consists of free gold associated with pyrite and probably some arsenopyrite and chalcopyrite locally. Calcite also has been reported to occur with quartz as the gangue material. The ore occurs in shoots which Dockweiler and Gilman reported as plunging 45° in the old workings. Oxidation has taken place in the upper parts of the veins to a variable degree, but probably has not extended much below the 97-foot level. Most of the gold extracted from the Last Chance mine is believed to have been from oxidized, free milling ore. The ore-shoots reportedly have been stoped out above the 97-foot level. Ore below the 97-foot level probably has been worked only in part because it is mainly primary, possibly of lower grade than the shallow oxidized ore, and more difficult to treat. It is not likely that large primary ore-bodies will be found at depth at the mine.

The main workings at the Last Chance mine total about 1,800 feet, including a main adit connected to a 241-foot shaft at 350 feet, 1,026 feet of drifts, several short winzes, crosscuts and drifts, and one or two abandoned shafts. These workings are located on the accompanying map (Figure 7) and shown in the schematic sections (Figure 8). At the time of this writer's visit in 1959, all of the workings were flooded below the 97-foot level and the drifts at that level were caved. The adit and main shaft were open, although a wood floor blocked the shaft about 20 feet below the collar.

Another vein, 3 to 11 inches wide and striking N. 45° E., is said to intersect the main vein near the center of the claim. It is developed by a 110-foot drift adit driven to the northeast. Twenty-five feet from the face of this adit is a 25-foot inclined winze sunk to the north. Other workings may exist and the reader is referred to Irelan (1888, p. 405), Preston (1893, p. 206), and Crawford (1894, p. 184).

There is no published record of the work done by Charles J. Wonder, who leased and developed the mine from 1938 to 1941. Because Wonder produced sulfide-type ore, it is probable that he worked below

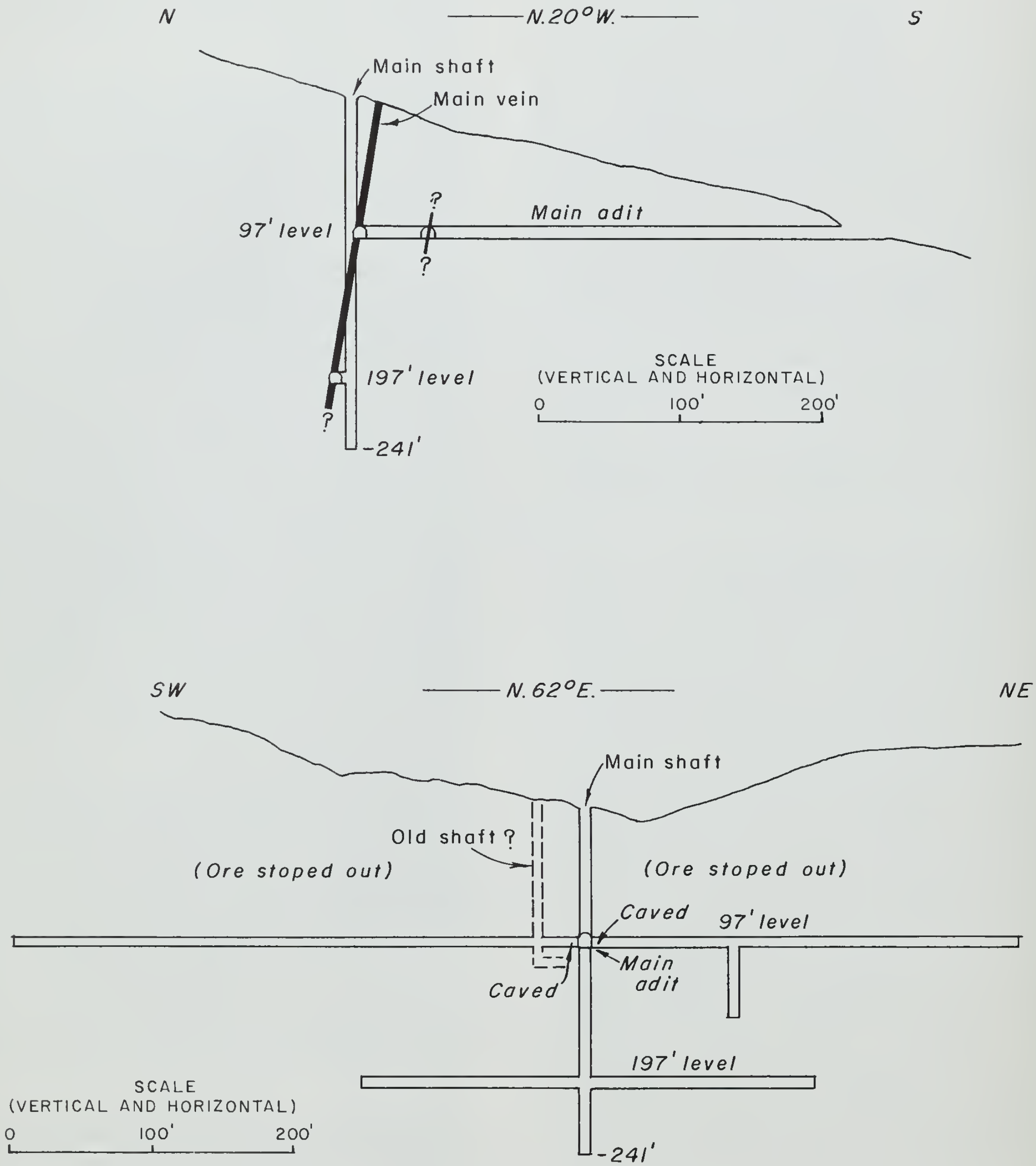

Figure 8. Schematic vertical sections showing the main workings at the Buclimo (Last Chance) gold mine. (Data shown are based on descriptions by Dockweiler and Gilman, 1910, unpublished report.)

the 97-foot level in the main workings. During this operation, 6 men were employed and a small mill was established on the adjacent Mary S claim. According to Mrs. Charles Wonder, widow of the lessee, Wonder concentrated the ore using a table and flotation cells. The concentrates were shipped to Selby for smelting.

Workings on the other patented claims of the Buclimo are not extensive and all were apparently exploratory. A 700-foot tunnel driven north from the West Extension No. 1 was not visited by the author, but is shown on the patent plat. In addition to that, a long drain tunnel starting on the Ora F No. 2 claim to the east was driven about 1,800 feet westerly to intersect and drain the Last Chance vein below the 400-foot level. This tunnel was never completed, being 300 feet short of the present shaft. Hill (1923, p. 328) stated that "the first 200 feet of crosscut is in medium-coarse sandstone; next there is 100 feet of black chert, and the remainder of the tunnel is in nearly black sandstone that is almost fine grained enough to be termed slate."

Two mineral specimens from the Last Chance mine displayed in the Monterey County case of the Mineral Exhibit, Division of Mines and Geology, San Francisco are:

#10074 Specimen of coarse, ragged gold in vein quartz; from the oxidized zone near the surface. (Donated by W. D. Cruikshank, 9/17/88).

#10075 Specimen of free gold associated with pyrite and arsenopyrite in ribbon-like quartz; from below the water table (about 120 feet deep?). (Donated by W. D. Cruikshank, 9/17/88).

Bushnell (Green Gold, Yellow Quartz) mine. Location: S½ sec. 22. T. 23 S., R. 5 E., M.D., reached via 3 miles of graded road east of State Highway 1, thence 3 miles northeast by trail to a point about 2,000 feet north and slightly east of the confluence of the North Fork of Willow Creek and a major north tributary. Ownership: Phil and Stewart Kinder, 13500 Old Morro Road, Atascadero, own 3 unpatented claims (Golden Quartz, Hidden Treasure, Caladonia); leased 1962 to G. A. Doyle, 792 Lewis Road, Watsonville, and James Pauley, Seaside.

John Bushnell discovered this lode about 1904 and located it as the Green Gold claim. U. S. Forest Service records show that the claim was relocated as the Yellow Quartz by G. A. Miller in 1924 and Mrs. J. Kinder in 1938, and as the Golden Quartz by Mrs. Jean Prival in 1940. Although the mine has been worked during several periods, recorded production is minor. According to unpublished data of the U. S. Bureau of Mines, total gold production amounts to $188, in 1912 and 1935. However production figures ranging from $9,000 (Hill, 1923, p. 329) to $150,000 (G. A. Doyle, January 1963, personal communication) have been reported by residents of the Los Burros district.

The Bushnell mine is developed along a northeast-trending vein at the intersection of a north-trending fault. Smaller veins also are found in the area. The veins cut Franciscan sandstone, which is locally slaty due to shearing. Apparently most of the development work was done by Bushnell prior to about 1920. This work is described by Hill (1923, p. 329) who visited the mine in 1921:

> "The developments consist of an incline shaft and a crosscut tunnel, 330 feet in all. The incline is sunk 130 feet on the intersection of a north-south fracture that dips about 50° E. and a N. 50° E. stringer that dips 50° SE. It is reported that about $9,000 in free gold was milled from the ore obtained in sinking this shaft. At the tunnel level the north-south fracture is barren; the N. 50° E. fissure ranges in thickness from a knife-edge to 8 inches and is filled with white quartz, calcite, and fragments of wallrock, the whole much crushed and shattered. A little free gold is visible in some of the quartz, but no sulphides, limonite, or other indications of the former presence of sulphides were noted in the ore."

Since Hill's visit, several owners and lessors have worked the mine intermittently and probably obtained some gold. According to G. A. Doyle (January 1963, personal communication), who leased the mine in January 1962, the mine was successively worked by Bushnell, (1904–1917), Henry Roberts and G. A. Miller (1923–1937), Phil and Stewart Kinder (1937–1941 and 1945–1947), Stewart Kinder and G. A. Doyle (1960–1962), and G. A. Doyle and James Pauley (since 1962). Workings reportedly consist of 330 feet of crosscut adits at the first and second levels, a 135-foot inclined shaft, 74 feet of winzes, 470 feet of drifting at various levels and sublevels, and considerable stoping. Drifting and stoping apparently extend northeast and southwest from the shaft and develop the main vein. Sketch sections of the mine, drawn by Doyle, indicate the upper workings to be caved and the lower ones to be open. The extent of the workings strongly suggests that total production exceeds the recorded production figure of $188. On the other hand, an estimate of $150,000 seems much too high as such production would be outstanding for the Los Burros district and would not likely escape documentation.

Grizzly (Ora F No. 2) mine. Location: SW¼ sec. 36, T. 23 S., R. 5 E., M.D., 8 miles by road east of State Highway 1 and 1,300 feet north of the Alder Creek campground. Ownership: Buclimo Mining Company, 1361 Seventh Ave., San Francisco. Unpatented claim.

The mine was located (or relocated) in 1889 as the Grizzly and was productive in 1890 and 1902-1904

under the name of Grizzly Mining Company (H.C. Dodge, Superintendent). The total recorded production of the Grizzly mine for those 4 years was $9,515 in gold and $33 in silver. A small production may also have been obtained between 1891 and 1894 when some development work was done at the mine. According to Hill (1923, p. 327), the vein is 3 to 4 feet wide and is composed of crushed sandstone with stringers of quartz and a little calcite. The vein strikes east-west and dips 75 degrees north. Mineralization consists of fine-grained gold associated with pyrite and arsenopyrite (Crawford, 1894, p. 184).

The Grizzly lode is developed by a 160-foot incline shaft from which much of the ore has been obtained. The shaft reportedly intersects a 50-foot drift or crosscut which connects the shaft with a 300-foot tunnel driven to the northwest. Presence of as much as 1,000 feet of tunnels were reported to the U. S. Bureau of Mines in 1903, but the locations and lengths of these tunnels are not known. When the mine was visited in December, 1959, the 300-foot adit was constricted at its entrance, but is said to be open beyond that point. The shaft was flooded to within 15 or 20 feet of the surface. Two other shafts are reported to be on this claim, but were not visited.

In the early days, the ore was crushed in an arrastra powered by a 30-foot overshot wheel situated on Alder Creek (Mining and Scientific Press, 1890, vol. 60, No. 10, p. 164). This was abandoned late in 1890 when the water gave out. In the early 1900's a 2-stamp mill was utilized and the free gold was collected by amalgamation. From 1902 to 1904, 197 ounces of gold was obtained from 72 tons of ore, or about $95 per ton at the present price of gold. Shortly, thereafter, the Grizzly mine was partly relocated as the Ora F No. 2 (see under Buclimo for a little more data).

A specimen of free gold with chalcopyrite in quartz from the Grizzly mine may be seen at the Division of Mines and Geology Mineral Exhibit (Monterey County case) in San Francisco. The specimen, number 12611, was donated by A. E. Moore in 1891.

New York mine. Location: NE¼ sec. 1, T. 24 S., R. 5 E., M.D., one mile by dirt road east of Alder Creek campground which is 8 miles by road east of State Highway 1. Ownership: John Lazier and Ade Harboldt, Pacific Grove, own three to four unpatented lode claims known as the New York, Triangle, California, and Good Deal (?).

The New York was discovered and located in 1901 by W. D. Cruikshank and Frank McCormack. The Triangle and California claims were located in 1908 and 1917, respectively. All known production from the New York mine came from the New York claim and the following discussion applies only to that claim. U.S. Bureau of Mines unpublished records show that W. D. Cruikshank in 1903, 1905-07, 1925, 1932-33, and 1935 and J. F. Harboldt in 1909 produced a total of 118.6 ounces of gold and 18 ounces of silver worth

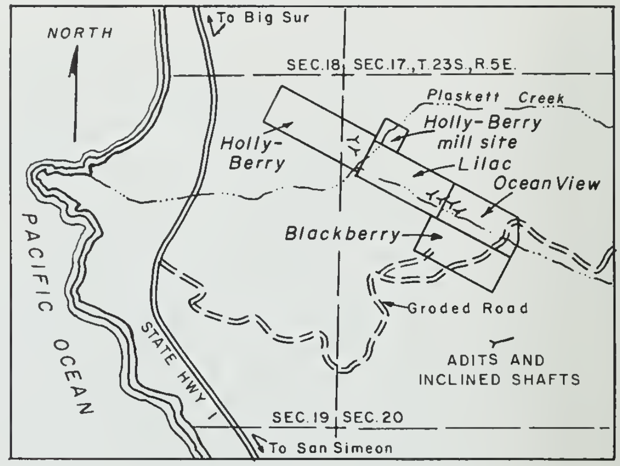

Figure 9. Map of Plaskett mine, showing approximate location of claims and main workings.

$2,540 from the New York mine. Goodwin (1957, p. 571) states that 1,300 tons of ore were produced, but this does not seem consistent with the value of reported production. Over most of the years of production, the mine was owned by Cruikshank and various members of the Lazier and Harboldt families (Laizure, 1925, p. 40). Little or no work, other than assessment, has been done at the mine since 1935.

According to Hill (1923, p. 327), the lode consists of "two narrow veinlets of quartz 18 inches apart" which have been crushed together with the intervening rock. The lode is mineralized with auriferous arsenopyrite and pyrite with minor amounts of chalcopyrite and galena. "Complete oxidation on this lode has extended to a depth of 50 feet and mining to that depth has yielded some fairly good free-gold ore". At the level of the 440-foot long adit, Franke (1935, p. 464) reported that gold values were in sulfides and were carried over a width of 20 inches to 3 feet or more. Except for a minor amount of free gold milled in the early years, most of the ore was concentrated and shipped to Selby for smelting. According to U.S. Bureau of Mines records, ore from the New York mine was low-grade and averaged considerably less than one ounce of gold per ton. Although some of the ore may have been hand-sorted and shipped directly to the smelter, most was treated in a small Straub mill and on a concentrating table before smelting. When the mine was visited in December 1959, most of the accessory equipment (table, motors, etc.) had been removed and the remaining mill, tracks and structures were in poor repair.

Judging from the workings, the vein probably strikes east. In 1935, the last year the New York claim was mined, the vein had been developed by a 440-foot adit to the south with a 195-foot drift east and a 95-foot drift west. The adit is reported to be open and the drifts caved. The intersection of the vein at the end of the long adit is judged to be about 150 feet

below the vein outcrop. A crosscut adit at the 200-foot level was reportedly being driven in 1935 and was 120 feet into the hill at that time. Other workings at higher levels were undoubtedly developed in the early days, but the extent of these is not known.

Plaskett (Howard; Ocean View) mine. Location: NE¼ sec. 19 and W½ sec. 20, T. 23 S., R. 5 E., M.D., in the vicinity of Plaskett Creek and a southwest tributary. Ownership: Jessie E. Plaskett, 123 Winham St., Salinas, and Violet M. Lowe, Gorda Station, c/o Big Sur, own the patented Lilac, Ocean View and Blackberry claims; Allvec Mining Co., 615 Walter B. Story Bldg., 610 S. Broadway, Los Angeles, owns the patented Holly-Berry claim and mill site.

The Plaskett mine or group consists of 4 patented lode claims encompassing at least 3 ore bodies, all discovered by F. M. Plaskett beginning May 1911 (Davis, 1912, p. 697) (Figure 9). These claims, which were patented in 1931, were developed intermittently from 1912 to 1950 and have yielded a recorded total of over $18,000 in gold (856 ounces) and silver (137 ounces). Production and development is about equally divided among the Holly-Berry, Lilac and Ocean View claims. During the early development, much of the gold was obtained from float below the vein outcrops.

Although the mine area was visited by this writer in 1959, there was no one on the property at the time and the mine workings were not entered. The country rock is Franciscan sandstone which generally strikes west or northwest. According to J. W. E. Taylor (1947, 4 pp., unpublished report for Allvec Mining Co.), the Holly-Berry claim is broken by longitudinal and transverse fractures, each set of fractures being partially filled with quartz. Gold mineralization is generally low-grade, except at the intersections of veins (fractures). Most of the gold produced was free-milling, oxidized ore. Similar geologic conditions exist at the Lilac and Ocean View claims to the southeast, where the narrow ore shoots also are predominantly oxidized. Alignment of the ore bodies with the linear tributary creek to the south suggests that both the creek and the deposits are located along a common northwest-trending fault system. At the Ocean View claim, the vein enclosing the ore body consists of crushed quartz, sandstone and black fault gouge and dips 10° NE at the surface, steepening to 60° NE at the bottom of the incline (Hill, 1923, p. 329). Maximum thickness of the vein is said to be 2 feet. At the adjacent Lilac claim the vein reportedly averages 3 feet thick, consists of quartz with some calcite, and is not particularly crushed. The hanging wall at both claims is "shaly-slate" and the footwall is sandstone (J. R. Lowe, personal communication, 1959). A sample of ore examined from the Ocean View or Lilac claim consisted of coarse flakes of gold in a brown, friable mixture made up predominantly of clay, quartz, and iron oxide. Coarse gold also is reported to be associated with vein quartz and fault gouge and some fine gold occurs with calcite. The ore was milled in an arrastra and, later, in a 3½-foot Huntington mill.

Available data concerning the history, development, and production of the Plaskett claims is as follows:

Holly-Berry claim—This was discovered in 1911 after heavy rains uncovered gold-bearing quartz float, which was then traced to the parent vein. Intermittent development in 1912-13, 1926-29, and 1931-34, resulted in production of 303 ounces of gold and 48 ounces of silver. Several adits one of which is about 300 feet long, have been driven west, and the deposit is further developed by winzes and stopes at the intersections of veins. According to Waring and Bradley (1919, p. 605), W. C. Howard leased and operated the deposit in 1914, but there is no record of his production. In 1945, the claim and mill site were acquired by Allvec Mining Co. No work has been done in recent years.

Ocean View claim—Discovered about 1912, records show that a total of 234 ounces of gold and 33 ounces of silver were produced by F. M. Plaskett (1913) and J. R. Lowe (1948-50). Prior to 1931, workings consisted of a 120-foot inclined shaft driven east-northeast on the vein with short drifts driven north and south at 50 foot and south at 120 foot depths. The upper south drift was intercepted by an adit from the west. In recent years, J. R. Lowe drove an 80-foot adit and a 30-foot southeasterly drift to intercept the old north drift. Some of the workings were reported to be accessible in 1959 (J. R. Lowe, personal communication).

Lilac claim—The mine was discovered about 1912 and worked 1913-1914 under the name Blanco (Blanch ?) McNeil by F. M. Plaskett. Production was 319 ounces of gold and 55 ounces of silver. Development consists of a 100-foot adit driven northeast at the end of which is a 60-foot drift to the northwest. The ore-body was worked by raising 4 inclined stopes, set on 20-foot centers, from the drift level to the surface. The vein dips 20-30° NE in the stopes (J. R. Lowe, personal communication). There has been no recent development.

Blackberry claim—Developed by only 2 small surface cuts, this claim was utilized principally as a mill site for the Ocean View claim prior to 1931. Ore from the Ocean View was conveyed via a 300-foot aerial tram from the inclined shaft to a 3½-foot Huntington mill erected at the north corner of the Blackberry claim.

Plaskett Placer deposit. Location: Approximately N¼ cor. sec. 27, T. 23 S., R. 5 E., M.D., near the confluence of the North Fork of Willow Creek and a major north tributary. Ownership: Not determined.

The first and probably only notable discovery of placer gold on the North Fork of Willow Creek was

made in 1902 by the Plaskett brothers (Davis, 1912, p. 698). The exact location of this deposit is not known, but local residents of the Los Burros area state that the Plaskett placer deposit was located on "Dogvine Creek" near its confluence with a north fork of Willow Creek (now described as the North Fork and a northern tributary to that fork). Davis reported that one gold nugget was worth $104 (about 5 ounces). About the same time, the U.S. Bureau of Mines recorded production for a Marion Placer claim in 1902 and an Oro Grande placer claim in 1903, both by Marion Plaskett. As there is no other record of placer production by a Plaskett, it seems probable that the Plaskett placer discovery referred to by Davis and the claims of Marion Plaskett are one and the same. The unpublished record shows that Plaskett worked bench or stream gravels by sluicing and obtained 191.56 ounces of gold worth $3,960 in 1902–1903. The fineness of the gold was reported to be 871 to 872.

Following that short period of mining, little or no production of placer gold was recorded for this deposit although numerous claims have been located and relocated in the same vicinity. However, small production of placer gold from unnamed claims and by snipers was recorded in the early 1900's. The Humbug placer claim, located in 1939 by Henry Voss, is believed to be a relocation of the Plaskett placer deposit. More recently, the Humbug claim was obtained by Fred Vaughn, who used the old Plaskett cabin on or near the claim. It is said that the cabin burned down during a heavy storm in the winter of 1955 and that 3 years later Vaughn worked the gravel at the cabin site. As a result, he reportedly found a large gold nugget worth $600 (about 17 ounces) which he gave to his brother. No production has been recorded for either Fred Vaughn or his Humbug claim. Because of difficult access to the Humbug claim and the uncertainty of its exact location, it was not visited by the writer.

Four other nuggets, varying from less than one ounce to 9 ounces, reportedly have been found along "Dogvine Creek" between 1959 and 1961 (G. A. Doyle, Jan. 1963, personal communication).

Spruce (South Fork of Willow) Creek placer deposits. Location: South Fork of Willow Creek mainly in N½ secs. 3 and 4, T. 24 S., and S½ sec. 34, T. 23 S., R. 5 E., but also extends to secs. 33 and 35. Ownership: Multiple—secs. 4 and 33 mostly homestead land in vicinity of South Fork of Willow Creek; secs. 3, 34 and 35 staked solid with active claims in 1960.

Placer gold was discovered on "Spruce Creek" (now designated South Fork of Willow Creek) at least as early as 1901 when the U.S. Bureau of Mines recorded moderate placer production for the Ralston Mining Company. This company continued to work the placer deposits of the creek through 1905, and a lode deposit in 1907, thus accounting for almost all of the recorded gold production from the Spruce Creek area. The Ralston Company apparently was succeeded in 1908 by the Gorda Mining Company which produced a small amount of lode gold from the Gorda mine in NE¼ sec. 4. Very minor lode production was also obtained in 1909 along Spruce Creek from the None Such claim by S. O. Pugh (see tabulation). The Gorda Mining Co. and others continued prospecting for gold-bearing gravels until about 1921, but with little success (Hill, 1923, p. 328–329). Minor additional placer production was obtained variously by F. J. Gillis, J. T. Gillis and H. B. Krenkel from Spruce Creek in the 1930's (see Tabulation under Gillis claims). Total recorded production since 1901 is 1,064 ounces of placer gold worth $22,075 and 65 ounces of lode gold worth $1,354.

Most of the placer mining in Spruce Creek apparently has been confined to local bench and steam gravels in secs. 3, 4, and 34. However, the creek in sec. 4 appeared to be quite rocky and lacked substantial gravels either in the creek or on benches along the sides. The creek banks are Franciscan rocks or are covered with talus debris. Some effort to hydraulic the talus deposits in NE¼ sec. 4 is evident from the presence of a water ditch and nozzles. Numerous short adits also have been driven to the north and south into the talus to find buried channel gravels and into bedrock to locate the source lode for the placer gold. Except for the Gorda and None Such claims (which see), no other lode near or along Spruce Creek has yielded gold. The placer gold found along Spruce Creek was reported to occur as "large ragged nuggets" (Hill, 1923, p. 328) and one nugget found on the Gorda claim about 1902 or 1903 was said to be worth $800 (Davis, 1912, p. 697). Another report (Engineering & Mining Journal, 1903, vol. 75, no. 21, p. 796) announced the finding of a nugget weighing 35.25 ounces on one of the Ralston Mining Company claims (possibly the same nugget as above).

LEAD

Galena (lead sulfide), the principal ore-mineral of lead, has been noted in several places in Monterey County, but never in concentrations that could be considered commercial. (See Silver in text; New York mine under gold in text; and Stonewall mine under gold in Tabulation).

LIMESTONE AND DOLOMITE

The extensive deposits of crystalline limestone and dolomite found in Monterey County are important resources for both current and future use. Limestone is composed predominantly of calcite ($CaCO_3$), and rock dolomite is composed chiefly of the mineral dolomite ($CaMg(CO_3)_2$). Collectively, these can be conveniently referred to as carbonate rocks. Many of the carbonate-rock bodies are composite; that is, they consist of both limestone and dolomite.

Most of the carbonate-rock masses in Monterey County occur as lenses associated with schist, gneiss, and quartzite of the Sur Series and various granitic

rocks. The carbonate-rock bodies have been referred to by several writers as the "Gabilan limestone", although they have no recognized stratigraphic position within the Sur Series. In some places the carbonate rocks are found, without other associated metasediments, as pendants in granitic rocks.

A majority of the limestone and dolomite deposits are in the northern Gabilan Range and in the Santa Lucia Range north of Chalk Peak. A few also are found along the San Andreas fault zone or scattered through the Sierra de Salinas.

Dolomite deposits of sufficient size and purity to be of commercial interest lie mainly in the Natividad district of the northern Gabilan Range. Virtually all of the dolomite produced has been quarried near Natividad, although a little may have been produced in the Sugarloaf Peak and Fremont Peak areas. It is estimated that approximately 5,000,000 tons of dolomite, including that used to make dolomitic lime, was produced from 1917 to 1961 in Monterey County. Kaiser Aluminum and Chemical Corporation's dolomite quarries at Natividad have accounted for most of this. At the north end of the same deposit is the old quarry of Pacific Coast Steel Company (later Bethlehem Steel Co.) where dolomite was quarried for many years prior to 1945 for use in lining the bottoms of open-hearth steel furnaces. A small amount of dolomite has been produced intermittently before 1925 by H. Bardin, C. Z. Hebert, C. Patton, Robert Porter, Edward A. Taylor, J. Braida, and O. D. Eastwood from several places near Natividad (Laizure, 1925, p. 36). Some of the dolomite produced in the early years was used for terrazzo, stucco dash, flux, lime, and carbon dioxide gas (Logan, 1947, p. 256).

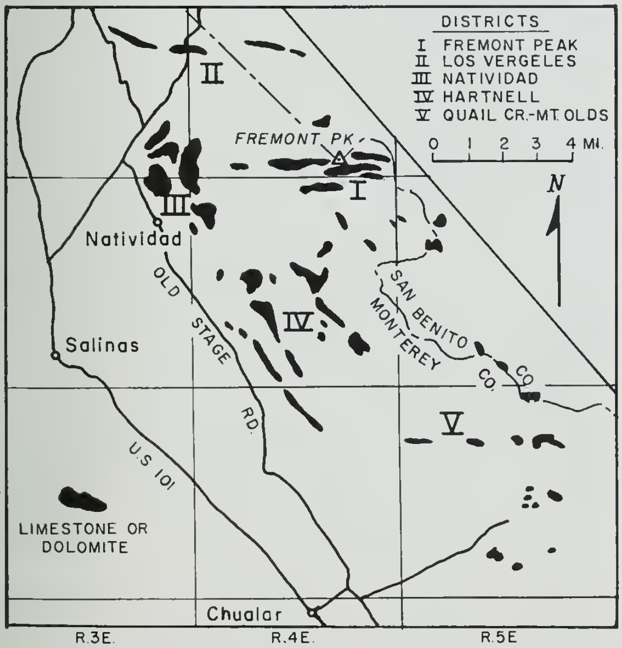

Figure 10. Limestone and dolomite districts in north Gabilan Range, and distribution of carbonate rock. (Geologic data after C. Jennings and R. Strand, 1958.)

In addition to the dolomite presently being quarried, future sources of dolomite in the county might be developed at the Porter Ranch deposit 1¼ miles east of Natividad or at other dolomite deposits as far north as Sugarloaf Peak. Several small masses of dolomite exist near Fremont Peak (Bowen and Gray, 1959, Pl. 1), but these are probably too small to be developed commercially.

Relatively pure limestone is more widespread than dolomite in Monterey County, and probably offers better possibilities for future development. Limestone was quarried commercially as a source of lime well before the turn of the century in both the Santa Lucia and Gabilan Ranges. A substantial but unrecorded amount of limestone was produced from the Limekiln Creek deposit near Lucia during the 1880's. From 1897 to 1917, records show that 64,480 tons of limestone worth $148,000 and 332,740 barrels of lime worth $368,497 were produced in Monterey County. The lime production is estimated to be equivalent to about 75,000 tons of limestone. Most of the limestone was calcined for use in the sugar beet and construction industries. Additional but unknown amounts of limestone have been produced intermittently as a source of aggregate, roofing and landscape granules, and building stone. The last limestone production was made in 1959 when Barnes Construction Company produced several thousand tons of landscape and roofing granules from the Quail Creek deposit.

Substantial future sources of good quality limestone are located at the Pico Blanco, East Gabilan and Bluerock Mountain deposits and possibly at the Limekiln Creek and Bixby Creek deposits. The Pico Blanco deposit is the largest in Monterey County and may be the largest limestone deposit within the San Francisco Bay marketing area. Several other large bodies of limestone are found in the Santa Lucia and Gabilan Ranges and in the San Andreas fault zone northwest of Parkfield, but these deposits have not been sufficiently prospected to determine their potential values. Numerous small limestone bodies of less than a million tons exist in many places in the county and may be useful for special purposes. Most of the significant limestone and dolomite masses are shown undifferentiated as "ls" on the geologic map (Plate I).

The deposits of Monterey County are described alphabetically below according to districts within the Gabilan Range, Santa Lucia Range, and San Andreas fault zone. A district classification is used in order to show the distribution of the carbonate rocks and to point out the common features of the deposits within a given district.

Gabilan Range

Limestone and dolomite deposits in the Gabilan Range extend from the northernmost parts of the range as far south as Chualar Canyon. Most of these lie within one of five groupings of deposits referred to herein as districts. The disposition of the various districts and the individual deposits is shown on Figure 10.

Photo 19. Detail of banded sequence of limestone and dolomite on the south slope of Fremont Peak. Commonly, the dolomite (gray bands) stands out in relief from the limestone and displays a cross-seamed texture resembling that of elephant skin. The limestone (white) is often typified by cup-shaped solution pits as at left. *Reprinted from Bowen and Gray 1959, photo 17.*

Fremont Peak District

The Fremont Peak district extends eastward from the Natividad district at Gabilan Creek to a point in San Benito County about 3 miles east of Fremont (Gabilan) Peak. Included within the district are several large east-trending bodies of carbonate rock in the vicinity of Fremont Peak and on Rocky Ridge to the west of the peak. Numerous smaller bodies are located east of the Peak. Most of the carbonate bodies consist of intermingled masses of limestone and dolomite that are not presently of economic interest. However, several deposits of limestone apparently are of suitable quality and size to be potentially economic at the present time. Bowen and Gray (1959, p. 28, 31, Pl. 1) have described these deposits as the Bardin Ranch, Fremont Peak, and East Gabilan deposits. None of these deposits has been developed commercially to date.

Bardin Ranch deposits. Location: SE¼ sec. 33 and SW¼ sec. 34, T. 13 S., and NW¼ sec. 3, T. 14 S., R. 4 E., M.D., about one mile west of Fremont Peak. Ownership: The Bardin Ranch embraces patented land which is part of the original Cienega del Gabilan grant.

Three patches of potentially commercial limestone have been mapped by Bowen and Gray (1959, p. 28 and Pl. 1). These patches are parts of two larger carbonate masses within the Sur Series–Santa Lucia granitic complex. Bowen and Gray briefly describe the patches as follows: "Part of the rock in these deposits is medium-grained, blue-gray material suitable for general use where color is not important, and part is coarse-grained, pure-white material suitable for whiting and white filler. None of the deposits has been developed or tested except for a few samples taken by the authors but, judging from surface exposures, more than a million tons of commercial material might reasonably be developed in the three masses. They are currently accessible by Gabilan Creek Canyon via unimproved dirt road."

East Gabilan deposit. Location: SW¼ sec. 36 (proj.), T. 13 S., R. 4 E., M.D., 1 mile east and slightly south of Fremont Peak and just west of the main ranch access road. Ownership: Reeves Ranch, but mineral rights leased to Ideal Cement Company.

According to Bowen and Gray (1959, pp. 28, 30, Pl. 1), "the East Gabilan deposit is the largest in the Fremont Peak district and is situated on terrain favorable to low-cost quarrying." The limestone deposit is a relatively pure portion of a large body of mixed limestone and dolomite. Bowen and Gray further describe the deposit as follows:

"As seen in plan, the limestone mass averages about 300 feet in width and is approximately 2,800 feet long. The beds, though crudely defined, strike N. 70-80° W. and dip 65-80° N. Erosion has exposed limestone to a depth of 140 feet below the highest outcrops and the

mass has been penetrated by several hundred feet of adits, driven for sampling purposes by predecessors to Ideal Cement Company. Although overlain stratigraphically by dolomite and dolomitic limestone, the stratigraphic sequence dips too steeply for such material to cause an overburden problem. Over most of the deposit there is no overburden whatever. Estimated reserves calculated to a depth of 240 feet below the uppermost outcrops (a reasonable recovery depth) total approximately 16,000,000 tons. Substantial additional tonnage could be developed by underground mining methods. The following analyses are typical of the limestone. Samples 1-3 were done by Ideal Cement Co.; samples 4-7 by Abbot A. Hanks Inc."

Chemical analyses in percent by weight (after Bowen and Gray, 1959, p. 30).

Oxide	#1	#2	#3	#4	#5	#6	#7
CaO	55.42	54.42	54.73	54.43	54.37	54.35	54.02
MgO	.41	.92	.41	.53	.45	.48	.99
SiO_2	.24	.94	1.52	.86	.86	.92	.82
Fe_2O_3	.20	.14	.32	.11	.08	.11	.13
Al_2O_3	.10	.14	.34	.29	.26	.17	.13
K_2O	.03	.02	.06	N.D.	N.D.	N.D.	N.D.
Na_2O	.04	.03	.02	N.D.	N.D.	N.D.	N.D.
P_2O_5	N.D.*	N.D.	N.D.	.06	.03	.02	.02
Ignition loss (chiefly CO_2)	43.72	43.53	43.18	N.D.	N.D.	N.D.	N.D.

* Not determined

Fremont Peak deposit. Location: S½ sec. 35 (proj.), T. 13 S., R. 4 E., M.D., about ¼ mile south and east of Fremont Peak and near Fremont Peak State Park road. Ownership: Reeves Ranch and Bardin Ranch, which are part of the original Cienega del Gabilan land grant.

This deposit consists of four substantial masses of medium to coarsely crystalline limestone of typically light blue-gray color grouped about the south flank of Fremont Peak. These masses have been mapped and briefly described by Bowen and Gray (1959, p. 31, Pl. 1) who estimate the probable total reserves to be a million tons. Three samples of representative limestone were analysed by L. A. Caetano of Ideal Cement Company. The analyses are given below:

Chemical analyses in percent by weight (after Bowen and Gray, 1959, p. 30).

Oxide	Sample G-13	Sample G-14	Sample G-15
CaO	55.02	53.94	55.52
MgO	.69	1.53	.46
SiO_2	1.58	.42	.14
Al_2O_3	.58	.08	.17
Fe_2O_3	.30	.08	.13
K_2O	.03	.01	.01
Na_2O	.04	.01	.04
Ignition loss	42.14	43.62	43.60
(chiefly CO_2)	42.14	43.62	43.60

In addition to the main limestone deposits described above, small masses of relatively pure dolomite and limestone a short distance to the south and east have been mapped by Bowen and Gray (1959) and some of these may warrant future prospecting.

Los Vergeles District

The Los Vergeles district is situated about 2 miles north of the Natividad district. It includes a large number of limestone lenses and bodies that comprise a gently sinuous belt extending eastward about 6 miles from a point near Crazy Horse Canyon in Monterey County nearly to Queen Canyon in San Benito County. The limestone and other associated rocks of the Sur Series occur as roof pendants in the Santa Lucia Quartz Diorite, as shown on the geologic map of the San Juan Bautista quadrangle (Allen, 1946). The largest of these pendants lies near the west end of the district adjacent to Crazy Horse Canyon.

The color of the crystalline limestone varies from blue-gray to white and the texture ranges from medium-coarse to fine-grained. According to Bowen and Gray (1959, p. 23), the limestone exposures east of the San Juan Grade road and northeast of the Crazy Horse Canyon road show extensive contamination by dolomite and silica. Therefore, any commercial development, other than for construction aggregate, would require careful sampling and probably selective mining in order to obtain a rock of uniform grade. An analysis of select white rock, collected by the Division of Mines and Geology and analysed by Abbot A. Hanks, Inc., in 1957, showed 55.48 percent $CaCO_3$, 0.25 percent MgO, 0.18 percent SiO_2, 0.03 percent Fe_2O_3 and 0.08 percent Al_2O_3.

There has been little development of the limestone in the Los Vergeles district. A small tonnage of material was produced prior to 1923 (possibly in 1917, according to unpublished records) on the Los Vergeles Ranch from a quarry along the San Juan Grade road near W¼ cor. sec. 18, T. 13 S., R. 4 E. Some of this limestone was used by the Judson Iron Works, presumably as a steel flux (Laizure, 1925, p. 43).

Natividad District

Situated 6 miles northeast of Salinas, the Natividad district includes one of the most important dolomite deposits in California—the Natividad deposit. The district is bounded on the west, north and east by Gabilan Creek and on the south by the Hartnell district. The Sur Series carbonate rocks occur as pendants in granitic rock which has more or less assimilated or altered the other rocks (especially schist) of the Sur Series. The structural relations in the district are difficult to understand as: 1) the Sugarloaf deposit and pendants to the east generally trend northeast; 2) the Porter deposit at the south end trends east-west; and 3) the Natividad deposit shows a weak northwest elongation and obscure bedding that strikes N. 60–70° W. and dips 40–45° NE (Allen, 1946, p. 69). Dolomite predominates over limestone in the district, the former being nearly pure at the Natividad and Porter deposits. The dolomite deposits of "Sugarloaf Peak have been

Photo 20. Natividad dolomite quarry and plant of Kaiser Aluminum and Chemical Corporation. Dolomite is quarried at several levels (upper left) and conveyed to heavy media separation, crushing-screening, calcining, and storage sections below. Although dolomite is of high purity, granitic intrusions cause a high proportion of waste (center). *Photo courtesy Kaiser Refractories Division.*

extensively contaminated by iron oxides" and are commonly mixed with limestone, according to Bowen and Gray (1959, p. 25). Several other large masses of carbonate rock east of the Natividad deposit were mapped by J. E. Allen (1946), but he neither described them in the text nor differentiated the limestone from the dolomite.

Several individuals quarried dolomite from the Natividad district prior to 1925 (Laizure, 1925, p. 36), but the locations of their operations are not known. It is also possible that limestone was produced in small amounts for use as lime around the turn of the century (Allen, 1946, p. 67; Aubury, 1906, p. 73).

Natividad deposit. Location: NW¼ sec. 1 and NE¼ sec. 2, T. 14 S., and SE¼ sec. 35 and SW¼ sec. 36, T. 13 S., R. 3 E., M.D. (proj.), 6 miles northeast of Salinas and just north of Natividad. Ownership: Kaiser Aluminum and Chemical Corporation, 300 Lakeside Drive, Oakland, owns or controls more than 500 acres.

The early development of this deposit is not clearly recorded in the literature, but probably some of the dolomite operators listed by Laizure (1925, p. 36) and others (Boalich, 1921, p. 156; Logan 1947, p. 258) produced small amounts of dolomite here intermittently from 1900 to 1925. By 1926, Pacific Coast Steel Company began quarrying dolomite near the north end of the Natividad pendant, around the SE corner sec. 35. The operation was more or less continuous until 1937, when the company was succeeded by the Bethlehem Steel Company. The latter company continued quarrying dolomite until 1944. Since then Bethlehem Steel has purchased Natividad dolomite from Kaiser Aluminum and Chemical Corporation. In 1942, the latter company, then known as Permanente Metals Corporation, opened a dolomite quarry and processing plant one-half mile to the south, and built a seawater

Photo 21. Rotary kilns at Natividad calcining plant of Kaiser Aluminum and Chemical Corp. Two of the kilns are normally used to calcine dolomite, most of which is shipped to Moss Landing to be reacted with seawater. The third kiln is used to make deadburned dolomite, used as a fettling material by the steel industry. *Photo courtesy Kaiser Refractories.*

magnesia plant at Moss Landing in order to supply raw materials for making magnesium metal at their Permanente plant in Santa Clara County. Here caustic-calcined magnesia, derived from the reaction of sea-water and calcined dolomite at Moss Landing, was used as the raw material to make magnesium metal by the carbothermic process (Allen, 1946, p. 68–72). This operation ceased in 1945 after the demand for magnesium sharply decreased. Magnesium metal was also made at a U.S. Government plant operated by Permanente Metals Corporation at Manteca, San Joaquin County, from 1942 to 1944. At this plant, magnesium was made by the ferrosilicon process, in which calcined dolomite from Natividad and ferrosilicon were the raw materials used (Ver Planck, 1957, p. 316). After World War II, the company offset the decreased demand for dolomite (created by the cessation of magnesium processing) by constructing a basic refractory brick plant at Moss Landing to utilize more magnesia—and hence more dolomite. An operational change was made at the Natividad plant when a heavy-media separation (H.M.S.) unit was installed in 1952 to beneficiate the dolomite. The Moss Landing facilities have also been expanded several times since the war, most recently in 1957. The Moss Landing sea-water-magnesia and basic refractories plants of Kaiser Aluminum and Chemical Corporation are described under the section on Magnesite and Magnesium Compounds.

The Natividad deposit can be described simply as a large irregular pendant of crystalline dolomite in granitic rock. The pendant is exposed for three-quarters of a square mile in area and about 700 feet in relief. The internal geology of the mass is complex, the dolomite body having been penetrated by numerous irregular dikes and sills of granitic rock now largely decomposed. Additional fracturing and shearing has made it virtually impossible to selectively quarry high grade dolomite on a large scale. The composition of the dolomite is further complicated by silica and silicate minerals deposited along shear planes and adjacent to dikes. Where free from granitic and silicic impurities, the rock is uniformly white, medium to coarsely-crystalline, relatively pure dolomite (Bowen and Gray, 1959, p. 25). The company provided the following typical analyses for dolomite produced in 1962: 31.75 percent CaO, 20.30 percent MgO, 1.31 percent SiO_2, 0.20 percent Fe_2O_3, 0.35 percent Al_2O_3, and 46.09 percent CO_2. Except for the subordinate production of exceptionally white material for roofing and landscaping granules, none of the dolomite is selectively quarried. A relatively high quality, uniform product is maintained, however, by H.M.S. and other practices. It is estimated that approximately one-half of the mined material is wasted.

Kaiser Aluminum and Chemical Corporation has developed the deposit by a series of bench quarries (levels). The lower ones to the south, including the 625-foot bench, are inactive. Most of the dolomite is quarried from benches at the 700-, 775-, and 850-foot levels, which are north of the company's older workings and southeast of the old quarry of Bethlehem Steel Co. Benches at the 750- and 825-foot levels immediately to the south of the 1960 quarry operations are also worked to some extent. The highest and most easterly bench, at 900 feet, is nearly worked out.

Quarrying is conducted by benching at 75-foot intervals. The faces are blasted using ammonium nitrate in 9-inch diameter holes drilled by rotary methods to 85 feet. Generally, a total of 30 to 40 holes are drilled on 25-foot centers and arranged in 3 parallel rows for each blast, which breaks a 2 to 3 month supply of rock. Some secondary blasting is necessary to reduce the larger blocks. The rock is loaded by two 4½-cubic yard capacity, electrically powered shovels into large capacity dump trucks which haul a short distance to the large primary crusher located at the 700-foot level. Much of the decomposed granite is wasted as the rock is fed over a grizzly to the jaw crusher. The material is crushed to about 4 inches, then passed over a half-inch mesh screen where the fines including some granitic material, are wasted. The oversize rock is next conveyed to a stockpile at the washing and H.M.S. sections located about 250 feet lower in elevation.

At the washing section, the dolomite is scrubbed in a Hardinge mill and passed through an attached trommel screen, both of which are supplied with fresh wash water. Rock larger than 3¾ inches is sent to a secondary jaw crusher and recycled to the scrubber. The minus fraction is washed over a ⅜-inch mesh screen, the fines going to a thickener and then to a waste pile. The plus ⅜-inch dolomite is next conveyed to the H.M.S. section for additional beneficiation. At this point, virtually all of the decomposed granite and other "soft" impurities have been removed from the rock.

The H.M.S. section was added to the processing plant in 1952 to remove the harder, siliceous and granitic impurities so that a high quality dolomite product could be obtained. This H.M.S. process has been described in detail by Lenhart (1953, p. 89-93), Utley (1952, p. 94–96) and others. The heavy medium is a suspension of finely-divided ferrosilicon and magnetite in water which is kept at a specific gravity of 2.7. Impurities lighter than 2.7 are floated off and join the sludge from the thickener and wasted (the light weight "impurities" actually appear to be very sound and probably would be useful as an aggregate for structural purposes). The heavier and purer dolomite (maximum sp. gr.—2.85) sink in the heavy medium and are removed from the H.M.S. cone by an air lift. Next, the heavy faction is washed over a screen and conveyed to the stockpile at the calcining plant below. The ferrosilicon and magnetite are reclaimed from the heavy medium by a sequence of steps including magnetizing, thickening, magnetic separation and demagnetizing.

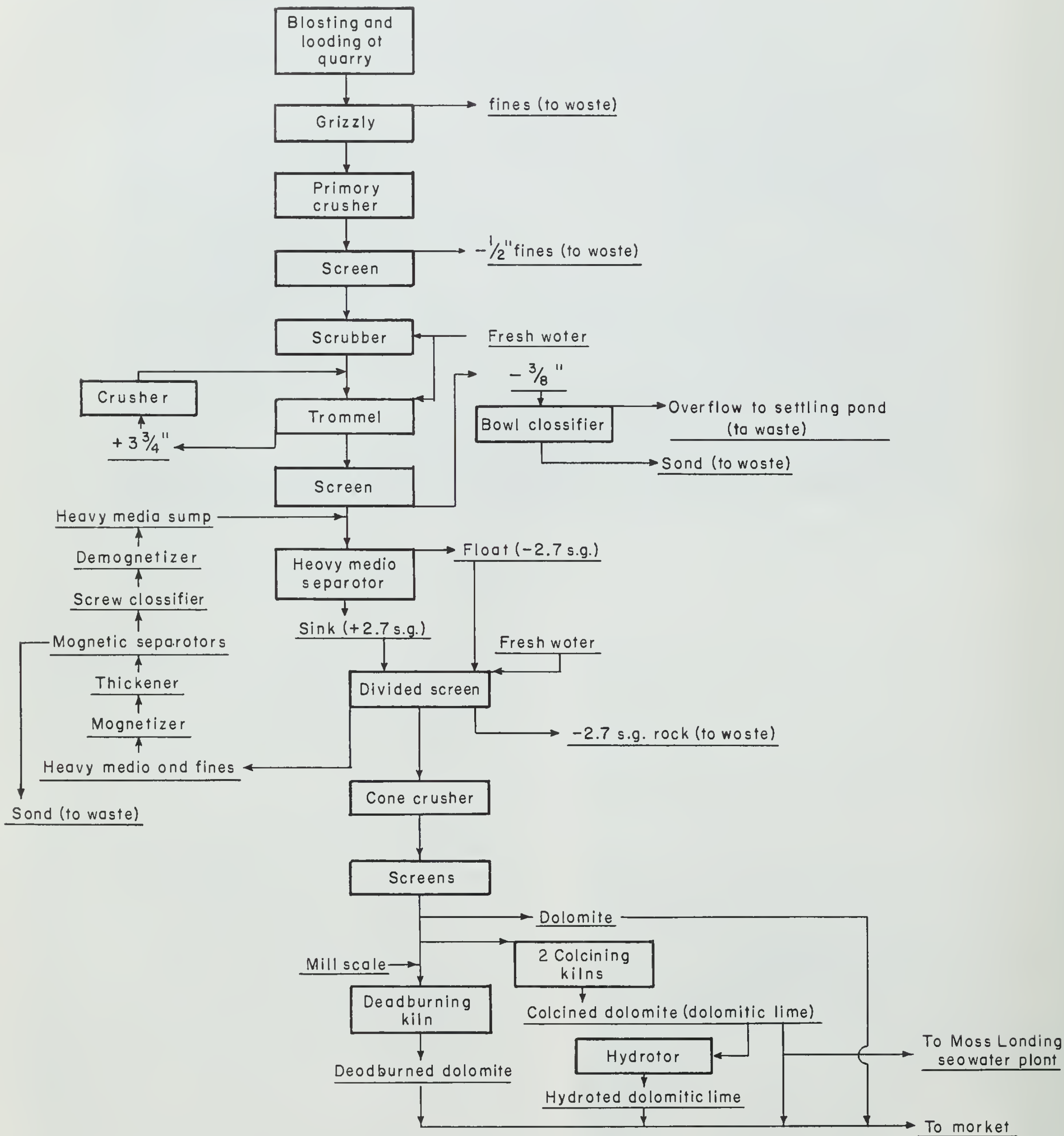

Figure 11. Flow sheet of Natividad dolomite quarry and processing plant, Kaiser Aluminum and Chemical Corporation.

At the calcining plant, the dolomite is crushed and screened to ½- by ¾-inch and minus ½-inch sizes for calcining in one of 3 gas-fired, rotary kilns. Two of the kilns are used to make caustic calcined dolomite; the third to make deadburned dolomite. Additional processing and equipment data are given by Taeler (1965). Most of the calcined dolomite is shipped in 25-ton trucks to the company's seawater magnesia plant at Moss Landing. The rest of the calcined dolomite, some of which is hydrated, is used extensively in several forms by the chemical, building and agricultural industries.

Deadburned dolomite is produced by adding iron in the form of mill scale to the dolomite feed and burning at temperatures as high as 3300° F. This product is shipped in bulk or bags for use as a fettling material in electric and open hearth steel furnaces.

Dolomite for roofing and landscape uses is selectively quarried and apparently processed separately in order to obtain a uniformly white material. In addition, dolomite fines from the crushing plant are used for marking athletic fields and soil conditioning. Crushed dolomite is also sold to the steel industry for use in maintaining open hearth furnaces.

Porter deposit. Location: W½ sec. 7 (proj.), T. 14 S., R. 4 E., 1¼ miles east of Natividad. Ownership: James Porter, 701 Old Stage Road, Salinas.

This undeveloped dolomite deposit has not been visited by this writer, but has been described briefly by Bowen and Gray (1959, p. 28) as follows:

"The deposit is roughly 300 feet wide and 3,000 feet long, with an east elongation and nearly vertical dip. Granitic intrusions penetrate the mass in many places. Most of the rock is white, medium crystalline dolomite similar to that in the Kaiser deposits. Three adjacent 10-foot-long chip channel samples cut perpendicular to the strike probably reflect the chemistry of the deposit. Much of the deposit corresponds to samples 2 and 3."

Chemical analyses in percent by weight (after Bowen and Gray, 1959, p. 28).

Sample No.	Fe	SiO_2	Al_2O_3	CaO	MgO	S	P	Mn	R_2O_3	CO_2 & H_2O
1	.10	1.52	.38	41.20	11.20	.004	.010	.06	.52	45.64
2	.40	.68	.30	33.00	20.67	.003	.008	.05	.90	45.10
3	.20	.84	.21	32.00	20.35	.003	.006	.05	.50	46.53

Sugarloaf deposit. Location: NW¼ sec. 36 and S½ sec. 25 (proj.), T. 13 S., R. 3 E., M.D., 7 miles northeast of Salinas. Ownership: Not determined.

Bowen and Gray (1959, p. 28) have described the Sugarloaf deposit as follows:

"A broad belt of carbonate rock 600 to 700 feet wide and over a mile long crosses Sugarloaf Peak, in a northeasterly direction. The southwest third of the mass is mainly dolomite but toward the northeast this grades into mixed dolomite-calcite rock. Northeast of the crest of the peak the mass is poorly exposed because of thick brush and soil mantle. Thus far, there has been no commercial utilization of the Sugarloaf Peak rocks.

"The dolomite is grayish-white, mottled with small spots and clots of red iron oxide. Veinlets of iron oxide and ferruginous silica cut the mass in numerous places. Where the carbonate mass is poorly exposed east of the peak, float consists of medium-grained, and coarse-grained blue-gray to white dolomitic limestone and finer-grained off-white dolomite.

"Because of the impure nature of the dolomite on the southwest slope of Sugarloaf Peak and because of the apparent mixture of calcite and dolomite rock east of the peak, it is doubtful if satisfactory commercial deposits can be developed in this vicinity."

Another broad northeasterly-trending belt of carbonate rock is shown by Allen (1946, Pl. 1) in sec. 36 a short distance southeast of the Sugarloaf belt. Nothing is known concerning the quality of limestone or dolomite in this large mass, but Allen (p. 67, 72, and Pl. 2) states that limestone was obtained from a quarry at the top of the hill one-half mile south of Sugarloaf Peak. This limestone was reportedly burned in an old brick kiln located at the forks of Gabilan Creek one mile northeast of Sugarloaf Peak.

Hartnell District

The Hartnell district is a northwest-trending group of carbonate masses lying southeast of the Natividad district and northwest of the Quail Creek-Mount Olds district (see Figure 10). It includes numerous small to moderate-sized carbonate masses, most of which lie within the south half of T. 14 S., R. 4 E. on the J. C. Bardin and Barnes ranches.

Bowen and Gray (1959, p. 37) examined some of the pendants and found them to "consist either of intermingled dolomite and calcite rock or of carbonate rock intermingled with granitic rocks, and quartz-mica schist. Although small masses of white limestone and white dolomite of acceptable continuity and satisfactory commercial quality probably can be developed in the Hartnell district, it is doubtful if many of these exceed 200,000 tons." The only large potential source of limestone known within the district is the undeveloped Bluerock Mountain deposit (described below).

The only limestone deposits utilized in the past were those of Spreckels Sugar Company. That company developed quarries in the NE¼ sec. 20 and NE¼ sec. 30, T. 14 S., R. 4 E., and possibly other quarries near Alisal Creek about the turn of the century to supply limestone (lime) for use in processing sugar. The Spreckels limestone quarries also supplied crushed rock to the construction industry. The white, coarsely crystalline limestone used to make attractive rubble masonry in Salinas was from these same quarries (Aubury, 1906, p. 73). It is estimated that more than 50,000 tons of limestone were produced from the Hartnell district prior to 1905. No limestone is known to have been quarried since then.

Bluerock Mountain deposit. Location: SW¼ sec. 25, and SE¼ sec. 26, T. 14 S., R. 4 E., M.D., 9 miles east of Salinas and nearly 8 miles north and slightly east of Chualar. Ownership: Not determined, but part of original Cienega del Gabilan land grant.

This deposit, which lies on the west slopes of Bluerock Mountain, has been briefly described by Bowen and Gray (1959, p. 37): "It is an oval mass having a slight east elongation and underlies most of the SW¼ sec. 25 . . . Most of the mass appears to be medium crystalline, blue-gray limestone. Reserves probably aggregate many millions of tons." Although this deposit has never been developed, it is apparently worthy of some future sampling and exploration in order to assess the potential resources.

Quail Creek-Mt. Olds District

Carbonate rocks of this district have an easterly trend, extending discontinuously from Quail Creek near the W¼ cor. sec. 7 to the SE¼ sec. 11, T. 15 S., R. 5 E. The beds generally dip moderately to steeply south and strike east. Most deposits consist of both calcite and dolomite, which are interbedded locally with metamorphic rocks or are cut by granitic dikes or sills. It is not likely that large deposits of uniform quality limestone will be developed here, but small ones may be useful in the future.

Production to date has been modest and is limited to the Quail Creek deposit. Limestone was quarried as a source of lime at the west end of the deposit many years ago. The only other development was in 1959 when Barnes Construction Company produced mixed carbonate rock for roofing and landscape uses.

Quail Creek deposit. Location: N½ sec. 7, T. 15 S., R. 5 E., M.D., about 10 miles by paved and graded roads northeast of Chualar. Ownership: Hazel Hurt, Salinas, leased to Barnes Construction Company, 2556 Mission Street, San Marino; originally part of Cienega del Gabilan grant.

At the west or northwest end of the Quail Creek deposit, a quarry (or series of pits) was worked near Quail Creek as a source of limestone for lime in the early 1900's (Bowen and Gray, 1959, p. 37; O. E. Bowen, 1961, oral communication). Possibly this quarry was operated by J. C. Jens, who produced limestone from near Chualar from 1910 to 1913 (unpublished records) or by Spreckels Sugar Company who operated a quarry nearby prior to 1910 (Laizure, 1925, p. 43). However, no lime kilns were observed by Bowen near the quarry site. Apparently the deposit lay idle until 1959 when Barnes Construction Company of San Marino developed a large quarry on the south slope of the ridge just east of the first development. In April 1960, this operation was inactive, although stockpiles and equipment remained at the quarry.

This deposit consists of several narrow lenses or beds of carbonate rock that extend easterly from Quail Creek a distance of about one mile and dip 30°–50° S. The beds are interleaved locally with schist and the whole has been penetrated by granitic dikes and sills. The main lens attains an estimated maximum thickness of 150 feet, including schist and granitic salients, but is much thinner at its extremities. It consists of fine and coarse crystalline calcite and medium crystalline dolomite, which occur together in varying proportions to form limestone, dolomitic limestone and dolomite. Because the limestone and dolomite beds are similar in attitude to that of the south slope of the ridge on which they occur, the deposit appears to be much thicker than it is.

Barnes Construction Company first developed the deposit in early 1959 by stripping the soil and caliche cover and by trenching and drilling. This was followed by quarrying later in 1959 and possibly in early 1960. The quarry is more than 1,000 feet long and has an estimated maximum relief of 150 feet. The face, which probably slopes an average of 40°, has been benched erratically, suggesting that the operator attempted to quarry selectively. By means of cut and fill, the quarry floor has been extended 200–300 feet out from the toe of the face. Although not active when visited in April 1960, the limestone apparently was blasted, loaded and transported to a bench about 20 feet above the quarry floor. By passing the broken rock over a grizzly on an inclined chute from the bench to the quarry floor, some of the decomposed granitic and other deleterious fines were removed. The material was subsequently crushed and screened by portable equipment to 6 different sizes, estimated as follows: plus 6-inch, 6 x 1½ inches, 1½ x ¾ inches, ¾ x ⅜ inch, ⅜ x ⅛ inch, and minus ⅛-inch fines. These sizes were stored in six conical piles ranging from 10 to 20 feet high. In addition, several thousand sacks of roofing granules (⅜ x ⅛ inch) and landscape rock (¾ x ⅜ inch) were stacked on pallets and several pieces of portable equipment (scraper, loader, forklift, conveyor and sacking machine) remained at the quarry.

The stockpiled rock fragments examined at the quarry ranged from relatively pure limestone through dolomitic limestone and dolomite, with minor amounts of granitic and schistose rocks. Most of the pieces were nearly white, but scattered iron-stained and gray fragments tended to give the crushed rock a slight tan to gray cast. Because of its heterogeneous composition and color, the limestone is probably unsuitable for use in cement, lime, steel flux, white fillers and other uses where chemical or certain physical uniformities are required. However, the rock is reasonably sound and might be well-suited to various roofing, landscape, agricultural and structural uses. A grab sample from one of the stockpiles was analyzed in 1962 by Lydia Lofgren of the Division of Mines and Geology and showed 17 percent MgO, 36.25 percent CaO, 2.4 percent Fe_2O_3, and 0.42 percent SiO_2.

Production cannot be determined from observation because of the irregular development of the quarry, but the amount of carbonate rock produced may exceed 100,000 tons. It is apparent that much of the quarried material was wasted and substantial amounts were used to construct a road to the quarry. According to unpublished records, the amount of carbonate rock sold for landscaping and roofing was much less than estimated production.

Reserves of the deposit are difficult to estimate because the dimensions of the limestone lens are not sufficiently well-known. Bowen and Gray (1959, p. 37) state that more than 2,000,000 tons of rock had been blocked-out, but presence of granitic rock and discoloration patches may result in a recovery of less than 50 percent.

Westphal Ranch deposit. Location: Secs. 10 and 11, T. 15 S., R. 5 E., M.D., on the south slope of Mt. Olds, 8 miles northeast of Chualar. Ownership: Herald Ranch (a trust estate), Herb G. Meyer, 145 Auburn Street, Salinas.

The Westphal Ranch deposit, which includes the two most easterly carbonate masses of the Quail Creek-Mount Olds district (Figure 10) is described by Bowen and Gray (1959, p. 38–39) as follows:

"The beds are sinuous but have a general east strike and a steep south dip. The carbonate rocks are interbedded with quartz-mica schist and quartzite, and some skarn-rock has developed along granitic contacts. None of the lenses exceed 200 feet in width and they are scattered along more than a mile of strike length. The rock is medium- to coarse-crystalline and blue-gray to nearly white. The chemical variations (in percent) based upon nearly 100 surface samples are indicated in the following table:

Fe	SiO_2	Al_2O_3	CaO	MgO
.15–.30	.28–5.2	.07–.63	32.9–53.8	2.0–18.2
S	P	Mn	R_2O_3	CO_2 and H_2O
.01–.005	.001–.13	.02–.06	.54–.93	42–44

"Because of the heterogeneous nature of the deposit, uniform rock can only be obtained in masses containing less than 1,000,000 tons each; many are much smaller than this."

Other Deposits in the Gabilan Range

Carbonate rocks outside of the districts described above are known in the vicinity of Chualar Canyon, north of Mt. Olds, and at the head of Gabilan Creek in the Swamp Creek area. Except for the latter deposits, which may be partly included with the Powerline deposits of Bowen and Gray (1959, p. 32), little or nothing is known about these scattered deposits of carbonate rock. They are probably small and, for the most part, are somewhat less accessible than the deposits described above.

Additional deposits not shown on Plate I may also exist in the Gabilan Range. For example, Logan (1947, p. 259) mentions an undeveloped limestone deposit, the Chalone deposit, about 6 miles east of Metz in the southeast part of T. 17 S., R. 7 E. However, nothing more is known of this relatively inaccessible deposit.

Santa Lucia Range

Crystalline limestone and dolomite deposits constitute an important part of the Sur Series, which is exposed in many parts of the Santa Lucia Range. The largest and most important deposits, however, occur close to the coast in what is herein called the Coast Ridge district. Smaller deposits exist elsewhere in the range, including the Sierra de Salinas, but are not spaced close enough to constitute a district.

Coast Ridge District

The Coast Ridge district encompasses a northwest-trending group of carbonate rocks of the Sur Series that extends for more than 35 miles along the Monterey coast from Bixby Creek on the north to Chalk Peak on the south (Plate I). It is confined to a 3-mile wide zone, which is approximately defined on the southwest by the Sur and McWay faults and on the northeast by the Palo Colorado and Coast Ridge faults. The carbonate rocks are generally white or nearly white, fine to very coarse crystalline limestone that is locally dolomitic. In many places, silica and silicate minerals have developed adjacent to granitic contacts, thereby rendering some of the limestone uneconomic. Although most of the deposits have been visited only briefly or not at all, the writer is inclined to believe that a great many of the limestone bodies delineated on the geologic map (Plate I) consist of multiple small limestone lenses interbedded with schist and intruded by granitic rocks.

The largest deposit in the district is the Pico Blanco limestone mass which apparently contains in the order of 600,000,000 tons of good quality limestone. No other deposit in the Coast Ridge district compares with this in size, but substantial reserves of limestone may exist in the Limekiln Creek area, Bixby Creek-Bixby Mtn. area, and elsewhere. One of the most important deterrents to the development of these limestone deposits is their inaccessibility, there being no railroad or heavy duty highway into the area. Additionally, the coastal portion of the Santa Lucia Range is considered an important recreational and wilderness region, and many interests would undoubtedly oppose large scale mining. Nevertheless, the development of one or more of the deposits probably will be desirable in the future, from the point of view of mineral economics.

Bixby Creek deposit. Location: N½ sec. 16, T. 18 S., R. 1 E., M.D., just north of Bixby Creek and 2 airline miles east of State Highway 1. Ownership: Not determined.

This deposit was operated from 1904 to 1910 by Monterey Lime Company of San Francisco. During

Photo 22. View northeast of Limekiln Creek showing carbonate rock outcrops on peaks in background and upper right. The Limekiln Creek deposits extend more than 5 miles southeast. They are little explored, partly because of the remote location and high relief. *Photo by Mary Hill.*

this period, that company produced an estimated (based on unpublished records) 75,000 tons of limestone, most or all of which was calcined in three large, upright, wood-fired kilns. When last visited in 1954 by Division of Mines geologists, the kilns were still fairly well preserved, although no longer usable. As there was neither a road nor a railroad into this area, the lime was hauled by overhead tramway to Bixby Landing on the coast where it was loaded onto ships waiting offshore.

The limestone was obtained from several small quarries near N¼ cor. sec. 16 just north of the lime kilns. However, the limestone removed from the quarries appears to be less than the 75,000 tons produced and it is probable that large boulders or other quarries also were used as limestone sources (O. E. Bowen, 1961, oral communication). The limestone is mostly white and coarsely crystalline, often containing concentrations of graphite in coarse crystals. The quarries are located near the center of a somewhat discontinuous northwest-trending mass of limestone that locally has been brecciated and is cut by numerous salients of granitic rock. The better material at the quarries is typified by analyses of 3 random-type samples collected by O. E. Bowen, Jr., in 1954 and analyzed by Abbot A. Hanks, Inc.

Chemical analyses in percent by weight.

Sample	SiO_2	Fe_2O_3	Al_2O_3	CaO	MgO	P_2O_5
1	3.84	.10	.18	51.82	1.04	.02
2	1.82	.08	.38	52.80	1.22	.03
3	1.96	.12	.30	52.93	1.06	.03

Future development of this deposit is limited by its small size, impurities, and relative inaccessibility. Numerous additional limestone masses are found on the flanks of Bixby Mountain between 1 and 3 miles to the southeast of the Bixby Creek deposit. The limestone, which is similar to that at Bixby Creek, has been mapped by P. D. Trask (1926, map) as many large continuous masses, the largest being one and a half miles long and nearly one-half mile wide. O. E. Bowen, in a brief inspection of the Bixby Mountain deposits, reports that the "large" limestone masses are made up of numerous smaller masses intermingled with schistose and granitic rock. Although a large deposit of limestone may not be expected to be here, moderate-size to small deposits of limestone of commercial quality may be determined by additional exploration and sampling. Chemical analyses [1] of the typically white, medium- to coarse-grained limestone of Bixby Mountain indicate the main limestone mass is of good chemical quality:

[1] Data courtesy O. P. Jenkins from unpublished consulting report by M. E. Maddock and C. C. Carlson, 1961.

Chemical analyses in percent by weight.

Sample No.	SiO_2	Al_2O_3	Fe_2O_3	CaO	MgO	P_2O_5
B-1	1.32	0.78	0.02	54.09	0.54	0.12
B-2	1.04	0.53	0.03	54.19	0.68	0.09

Limekiln Creek deposits. Location: Secs. 10, SW¼ 11, NW¼ 14, and 15, T. 22 S., R. 4 E., M.D., 1-2 miles east of Lucia. Ownership: S. H. Cowell Foundation, 25 California St., San Francisco, and U.S. Government.

Numerous small to moderate-sized deposits of carbonate rock are reported between the main and west forks of Limekiln Creek. These are interbedded with schist of the Sur Series and are commonly cut by dikes of light and dark granitic rocks. Because carbonate rock talus is so prevalent in secs. 10 and 15, the impression is given that an immense carbonate body exists (see Reiche, 1937). However, O. E. Bowen (1964, personal communication) reports that the largest body present in this area is a northeast-dipping rib of carbonate rock averaging perhaps 100-150 feet thick. The rib is situated near the S¼ cor. sec. 10 and is best exposed on the west side of the main spur south of "hill 2449." The deposit is a complex mixture of massive, white, coarse-crystalline to platy, gray, banded, fine-crystalline limestone. Some of the limestone is dolomitic (cream-colored dolomite) and much is siliceous and commonly brecciated. The carbonate rocks have been contact metamorphosed, with various magnesium, calcium, and aluminum silicates being present. According to Bowen, other impure carbonate masses are found in the region, but most are small and none are of sufficient quality to be of significant economic interest.

The above carbonate deposits apparently extend discontinuously 6 miles southeast to the west flank of Chalk Peak in sec. 28, T. 22 S., R. 5 E. Where the carbonate belt crosses the connecting road between the coast and Jolon (between Chalk Peak and Limekiln Creek), the limestone masses are too thin and impure to be of commercial interest. The deposit indicated near Chalk Peak on the Geologic Map of California, San Luis Obispo sheet (1958), has not been examined.

The only limestone development in the vicinity took place during the 1880's by the Rockland Lime and Lumber Company who erected 4 vertical kilns along the West Fork of Limekiln Creek (SW¼ sec. 15, T. 22 S., R. 4 E). Crushed limestone and limestone debris from a large landslide situated on the steep slope northeast of the kilns were utilized. The company developed several shallow hillside pits in the crushed limestone and sledded the material down slope to the kilns. The kilns, each of which had a capacity of 110 barrels of lime per day, apparently were loaded overhead and fired by wood. Lime was hauled to Rocklands Landing about a mile away and loaded by aerial tramway aboard ships. Around 1890, the property was acquired and shut down by Henry Cowell Lime and Cement Company, and has been inactive since. Considering the wet climate and date of the operation, the limekilns are in remarkably good condition, from a historical viewpoint, although they are no longer usable.

The quarry vicinity was examined briefly in August 1959. Although good limestone was undoubtedly selected from the landslide debris for calcining, not all of the limestone is of good quality. Locally, the limestone is dolomitic and associated with metamorphic and granitic rocks, much like the main deposit higher on the spur. Some of the rocks appear to be in place and either represent Sur Series beds underlying a thin veneer of landslide debris or are portions of a large, partly crushed block that slid downslope from the main limestone mass. It is not likely that further commercial development will take place in this landslide area.

Pico Blanco deposit. Location: Sec. 25 and 36, T. 18 S., and secs. 1, 2, 11, and 12, T. 19 S., R. 1 E., M.D., 2 to 3 airline miles northeast of State Highway 1. Ownership: Granite Rock Co., P. O. Box 151, Watsonville, owns sec. 36 and unpatented mining claims in secs. 25, 1, 2, 3, 4, 11, 12, and 13 totaling about 2,800 acres.

The Pico Blanco deposit is probably the largest mass of good quality, uniform grade limestone within 150 miles of San Francisco. Although reserves appear to be enormous, the deposit never has been developed commercially because of its relatively inaccessible location and distance from major sources of transportation.

Sec. 36 of the deposit was acquired from the estate of Mrs. C. L. Koch about 1956 by Tom Maher, Pacific Grove, who also located many claims in the vicinity. Maher's holdings were obtained in the late 1950's by Olaf P. Jenkins of Pacific Grove. Jenkins had the deposit sampled and mapped in detail by M. E. Maddock (1960, unpublished report) and M. E. Maddock and C. C. Carlson (1961, unpublished report). Results of these surveys were kindly made available for this report. Granite Rock Company finally acquired the Pico Blanco property about 1963 after leasing for a short period of time.

Pico Blanco ("White Peak" in Spanish), refers to the white limestone which caps the summit and east and south flanks of the 3,709-foot peak. The deposit presently is accessible only by foot trail from the Old Coast Road (about 5 miles to the west) and from the Pico Blanco Boy Scout Camp (about 3 hiking miles northeast).

The deposit consists of two bodies of crystalline limestone of economic interest—known as the Pico Blanco body and the Hayfield body—and numerous smaller bodies of little commercial importance. The Pico Blanco body is a thick, irregularly-shaped mass that crops out over a distance of 2½ miles from north to south (see Figure 12). The northern part of the body dips 35-55° NE and appears to be a homocline, but the southern third is structurally complex, probably being a faulted, southeasterly-plunging anticline.

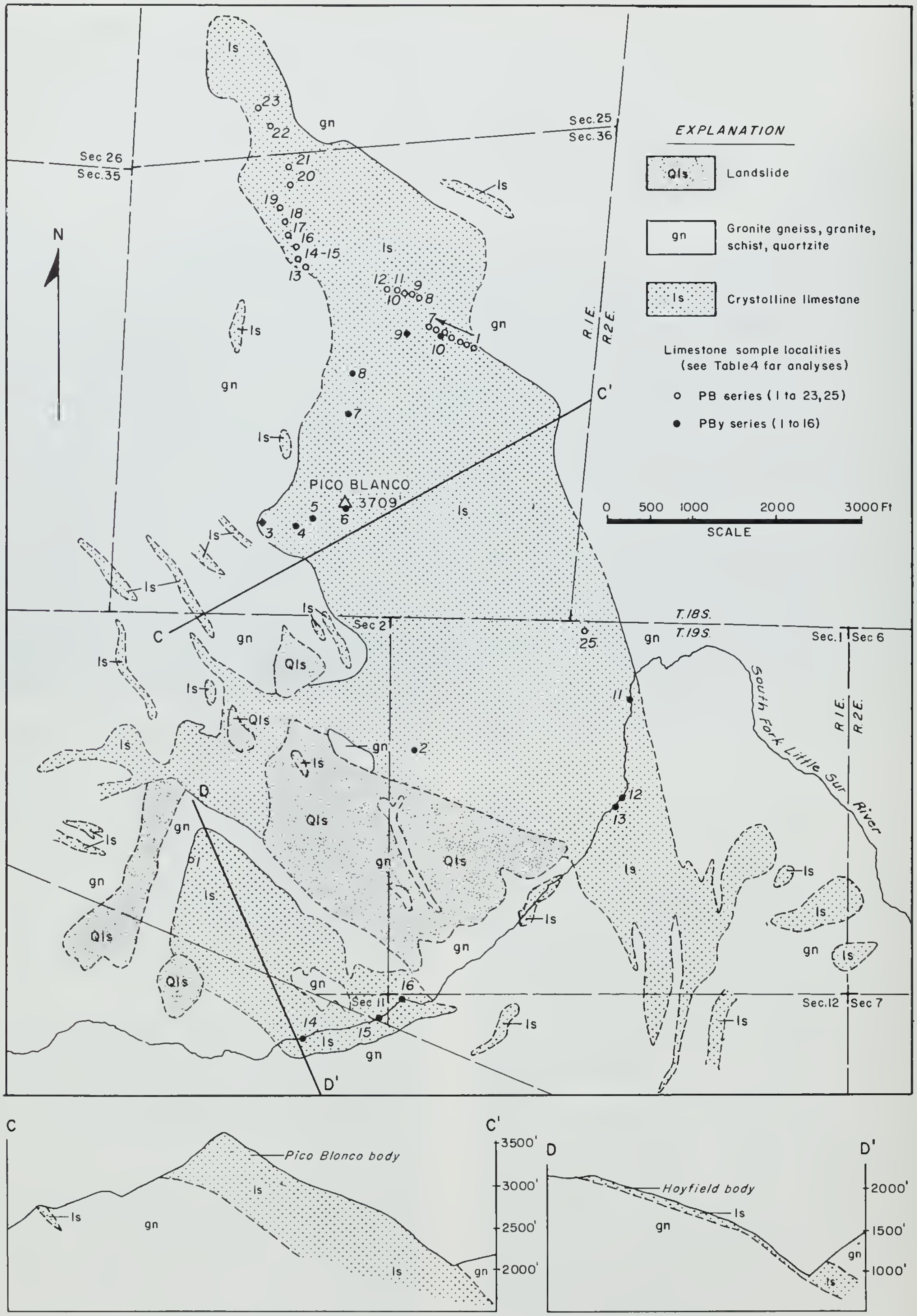

Figure 12. Geologic map and sections of Pico Blanco limestone deposit, showing sample locations. (Geology and sections after M. E. Maddock, 1960, unpublished report for Olof P. Jenkins.)

Southwest of the Pico Blanco body is the Hayfield body located in SE¼ sec. 1. This mass of crystalline limestone blankets the south slope of the peak and probably has a maximum thickness of 100 to 200 feet.

In large part, the Pico Blanco and Hayfield bodies consist of white or nearly white, coarsely crystalline limestone composed almost entirely of calcite, with minor amounts of quartz and graphite. Local concentrations of granular quartz in thin resistant bands exist, but they are quantitatively unimportant. Dolomite is also found in some places as alternating bands or disseminated crystals in the limestone. In one place along the South Fork of Little Sur River, banded dolomite constitutes a sequence 40-50 feet thick. Phlogopite (magnesium mica) in small "trains", and other magnesium silicate minerals occur locally. The dolomite, quartz and silicate minerals present would be considered as impurities in most limestone uses, although minor occurrences of these contaminants may be diluted to acceptable proportions by blending with high quality limestone during quarrying. Larger masses of impurities, which are not common, generally can be avoided by selective mining. If the limestone is used for cement, a high silica content may be desirable. Other contaminating materials associated with the limestone are schist and gneiss interbeds and granitic dikes. These rocks are usually restricted to the marginal parts of the limestone bodies and may not present serious mining problems.

Table 4. Chemical analyses of carbonate rock samples from Pico Blanco deposit (see figure 12 for locations)

Sample No.	SiO_2	Fe_2O_3	Al_2O_3	CaO	MgO	P_2O_5
PB-1	2.56%	0.08%	0.44%	53.66%	0.46%	0.04%
PB-2	0.69	0.04	0.17	54.92	0.48	0.02
PB-3	3.90	0.12	0.92	52.56	0.48	0.03
PB-4	0.17	0.02	0.04	55.52	0.26	0.04
PB-5	6.12	0.10	1.27	51.43	0.19	0.05
PB-6	0.55	0.13	0.14	54.54	0.83	0.01
PB-7	0.27	0.02	0.08	55.70	0.07	0.02
PB-8	0.13	0.04	0.04	55.69	0.14	0.01
PB-9	0.50	0.07	0.12	55.30	0.24	0.04
PB-10	0.47	0.16	0.10	36.88	15.89	0.02
PB-11	0.31	0.08	0.08	55.56	0.14	0.03
PB-12	0.81	0.05	0.22	54.87	0.42	0.01
PB-13	0.66	0.05	0.21	54.78	0.52	0.03
PB-14	0.20	0.06	0.08	55.58	0.18	0.02
PB-15	0.18	0.05	0.06	55.08	0.59	0.03
PB-16	2.78	0.03	0.88	53.29	0.42	0.01
PB-17	0.70	0.05	0.20	54.82	0.48	0.02
PB-18	0.84	0.06	0.24	54.89	0.36	0.02
PB-19	0.69	0.05	0.18	55.12	0.23	0.03
PB-20*	0.84	0.13	0.21	42.40	10.96	0.03
PB-21	0.67	0.06	0.16	50.35	4.33	0.02
PB-22	1.01	0.04	0.23	54.59	0.49	0.02
PB-23	0.22	0.02	0.07	55.35	0.39	0.03
PB-25	0.62	0.02	0.13	55.00	0.37	0.05
SPB-1	0.94	0.47	0.20	53.47	1.30	0.11
SPB-2	0.76	0.08	0.13	51.14	3.66	0.05
SPB-3	0.32	0.06	0.07	52.36	2.80	0.05
SPB-4	0.21	0.05	0.05	55.21	0.49	0.05
PBy-1A	0.70	0.08	0.14	55.04	0.33	0.20
PBy-1B	0.52	0.05	0.06	55.09	0.43	0.07
PBy-1C	0.66	0.06	0.14	52.13	2.77	0.21
PBy-1D	0.58	0.05	0.10	53.81	1.43	0.20
PBy-2*	23.40	0.14	0.38	42.28	0.17	0.05
PBy-3	0.72	0.07	0.15	53.96	1.19	0.21
PBy-4	3.10	0.08	0.16	53.32	0.57	0.14
PBy-5	0.88	0.04	0.08	55.09	0.24	0.04
PBy-6	1.18	0.02	0.06	54.65	0.49	0.04
PBy-7	1.92	0.03	0.10	54.56	0.41	0.05
PBy-8	1.48	0.05	0.18	54.25	0.59	0.19
PBy-9	0.72	0.10	0.20	55.17	0.18	0.20
PBy-10	2.16	0.16	0.32	54.01	0.38	0.20
PBy-11	7.32	0.19	0.36	50.47	0.71	0.26
PBy-12A	3.92	0.11	0.23	52.83	0.53	0.21
PBy-12B*	1.12	0.06	0.12	35.30	16.95	0.01
PBy-13*	17.94	0.19	0.22	44.83	0.58	0.04
PBy-14	0.70	0.08	0.16	54.71	0.64	0.20
PBy-15	0.44	0.03	0.11	54.31	1.08	0.19
PBy-16	1.74	0.04	0.14	54.58	0.23	0.05

* Sample analysed to determine range of SiO_2 or MgO or other special purposes.

Samples PB-1 to PB-12 collected by O. E. Bowen and E. W. Hart 3-27-57 and analysed by Abbot A. Hanks, Inc., San Francisco.
Samples PB-13 to PB-25 collected by O. E. Bowen 6-27-57 and analysed by Abbot A. Hanks, Inc.
Samples SPB-1 to SPB-4 collected by Tom Maher (previous owner) Mar. 1958 and analysed for Div. of Mines by Abbot A. Hanks, Inc.
Samples PBy-1 to PBy-16 collected by M. E. Maddock 10-1-59 (outcrops painted yellow) and analysed by Abbot A. Hanks, Inc. (permission to publish courtesy O. P. Jenkins, previous owner).

Through early 1961, development of the Pico Blanco deposit had been restricted to sampling and geologic mapping. One or two small test pits were blasted in the Hayfield body, but systematic sampling at these test pits had not been carried out. The present owner contemplates some core drilling and/or test quarrying in the future to determine the reserves of the deposit more accurately. Prior to 1961, samples from 44 localities (Figure 12) were analyzed for chemical composition (Table 4). Although an insufficient number of samples was analyzed to delineate areas of various quality limestone, sampling and field inspection indicate that the great bulk of the Pico Blanco and Hayfield bodies consist of good quality limestone that averages about 54 percent lime (equivalent to 96.5 percent calcium carbonate). It is apparent the limestone is of sufficiently high quality for cement. Moreover, analyses suggest that some of the limestone is adequate for most lime, chemical and metallurgical uses.

Reserves cannot be estimated accurately because exact thicknesses of the bodies are not known. However, if it is assumed that the Pico Blanco body has an average thickness of 500 feet, maximum limestone reserves north of the South Fork of Little Sur River and above 1,600 feet elevation are estimated to be in the order of 600,000,000 tons. Although parts of the deposit are thinner than 500 feet, a maximum thickness of over 1,500 feet is estimated by M. E. Maddock (1960, unpublished report) and the reserve estimate is probably conservative. On the other hand, reserves could be reduced significantly depending on the quality and uniformity of limestone required for a particular use, the amount of selective mining necessary, and the amount of deleterious materials associated with the limestone. By any standard, however, the Pico Blanco body is enormous and the most serious drawbacks to its development are 1) its relatively inaccessible location, especially with reference to major transportation lines, and 2) its location in an area of high recreational value.

The maximum reserves of the Hayfield body north of the river are estimated to be about 20 million tons,

assuming an average thickness of 100 feet. Any variation from this assumed thickness would affect reserves proportionately. Although estimated reserves are small relative to the Pico Blanco body, the Hayfield body is closer to transportation facilities and may be useful, especially during any early quarry development of the Pico Blanco deposit.

Sierra (Serra) Hill-Little Sur deposits. S½, T. 18 S., R. 1 E., M.D., extending from the NW¼ sec. 19 southeasterly to the E¼ cor. sec. 34, accessible from State Highway 1 and the Old Coast Road. Ownership: Not determined.

Several sinuous lenses of carbonate rock as long as one mile are shown on the geologic map of P. D. Trask (1926). These lenses plus some small masses form a discontinuous belt 4½ miles long trending from the sea coast just north of Hurricane Point southeast to the western part of Dani Ridge. Limestone in the area is virtually untested, and little is known about its commercial possibilities. The most northwesterly lens of limestone was observed briefly where it is crossed by Highway 1. Here, it is brecciated and somewhat impure, being associated with schist and locally cut by granitic dikes. One selected sample (LSL-1) of limestone was collected by O. E. Bowen, Jr., in 1955 and analyzed by Abbot A. Hanks, Inc.

Chemical analysis in percent by weight.

SiO_2	Fe_2O_3	Al_2O_3	CaO	MgO	P_2O_5
.56	.08	.30	54.13	1.02	.04

This sample represents the best limestone available near the Highway and is a nearly white, fine to coarse crystalline material. However, this part of the deposit probably is not commercial due to siliceous impurities, which were not sampled. Although the limestone lenses southeast of here also may be impure and somewhat shattered, their relative accessibility warrants further sampling and examination.

Other Deposits in the Santa Lucia Range

Outside of the Coast Ridge district, no well-defined districts or large carbonate masses are known in the Santa Lucia Range although many small scattered bodies have been mapped by Fiedler (1944), Reiche (1937), and others. However, four small deposits have been developed to a minor extent in the past—Lambert Ranch, Limekiln Creek (near Chualar), Tassajara, and Jolon deposits. A fifth deposit, the Junipero Serra deposit, is not developed but may be the largest undeveloped one beyond the Coast Ridge district. The Tassajara deposit was utilized only to make lime for mortar in the construction of the hotel at Tassajara Hot Springs, and the Jolon deposit has not been located. The other deposits are described below.

Junipero Serra deposit. Location: Sec. 6, T. 21 S., R. 5 E., M.D., approximately 40 miles by paved and dirt road west of King City. Ownership: Unpatented claims of Sparks, Pearson, and Bert Talcott (Salinas).

A narrow body of carbonate rock extends northwesterly for about one mile from the vicinity of Roosevelt Creek where it intersects the east boundary of sec. 6. The southeast portion of the carbonate body, examined in August 1957, consists of coarsely crystalline limestone containing abundant graphite flakes and possibly some silica. A typical sample collected from this area was analyzed by Abbot A. Hanks, Inc., in 1958:

Chemical analysis in percent by weight.

Div. Mines No.	SiO_2	Fe_2O_3	Al_2O_3	CaO	MgO	P_2O_5
SP-1	1.08	.16	.34	53.50	1.12	.10

Where sampled, the limestone mass has a maximum thickness of 150–200′ and dips steeply northeast into the southwest-facing slope of the hill. From this point, the limestone can be traced visually for nearly a mile to the northwest. The deposit is too narrow, steeply dipping, and remote to be developed at the present time, except possibly for special uses. However, additional prospecting is needed to determine the economic aspects more accurately. The deposit has not been developed.

Two miles to the northwest is another deposit of carbonate rock that is covered by the unpatented claims of Frank Watkins of Salinas. Two samples collected by Watkins near the Indians road, SW¼ sec. 36, T. 20 S., R. 4 E., were submitted to the Division of Mines in 1958. Analyses showed these samples to be impure dolomite:

Chemical analyses in percent by weight.

Div. Mines No.	SiO_2	Fe_2O_3	Al_2O_3	CaO	MgO	P_2O_5
Jun-1	3.88	.13	.53	34.31	16.26	.02
Jun-2	7.70	.17	1.62	37.77	10.10	7.11

Sample Jun-1 is a nearly white, very coarsely crystalline dolomite with some calcite and silicate impurities. Jun-2 is even more impure and has an unusually high phosphate content.

Near the Watkins deposit is a small mass of white, very coarsely crystalline dolomite that is relatively pure, except for a small amount of interstitial calcite. Other small masses of crystalline limestone are found to the north along the Indians road in SW¼ sec. 13 and NW¼ sec. 24, but they are probably too small and remotely situated to be commercial.

Lambert Ranch (Jamesburg) deposit. Location: SW¼ sec. 17, SE¼ sec. 18, and NW¼ sec. 20, T. 18 S., R. 4 E., 1½ miles southeast of Jamesburg. Ownership: Not determined.

The deposit consists of several small limestone lenses strung out for about one-half mile in a N. 20° W. direction and centering just east of the SW cor. sec. 17. The limestone is described by O. E. Bowen, Jr. (personal communication, 1961) as medium-coarsely crystalline and light blue-gray in color. It is developed by 2 small quarries, long ago abandoned. Because the limestone is partly silicated and the deposit small, it

probably is not of commercial interest. However, Bowen collected 3 samples in 1954 and had them analyzed by Abbot A. Hanks, Inc. The first 2 are from the north quarry and the third from the south quarry.

Chemical analyses in percent by weight

Div. Mines sample No.	SiO_2	Fe_2O_3	Al_2O_3	CaO	MgO	P_2O_5
LSL-2	.24	.09	.13	54.38	.99	Tr
LSL-3	.18	.08	.12	54.29	1.12	Tr
LSL-4	.16	.11	.13	54.39	1.06	Tr

Limekiln Creek deposit (near Chualar). Location: E½ sec. 28, T. 16 S., R. 4 E., M.D., approximately 4 miles south of Chualar. Ownership: Not determined.

Two small lenses of crystalline limestone in the Sierra de Salinas were developed by small quarries many years ago for the production of lime at a nearby kiln. Although the limestone is reported to be of fair quality, the deposit is too small to be commercial (O. E. Bowen, Jr., personal communication, 1960). Random samples were collected from each deposit by Bowen and analyzed by Abbot A. Hanks, Inc., in 1955.

Chemical analyses in percent by weight

Div. Mines No.	SiO_2	Fe_2O_3	Al_2O_3	CaO	MgO	P_2O_5
LSL-8	.32	.09	.21	53.53	1.66	.03
LSL-9	.54	.06	.30	52.81	2.07	.02

Several other carbonate masses are found in the Sierra de Salinas to the northwest of this deposit, but are of difficult access and have not been examined (see map, Plate I).

San Andreas Fault Zone

Deposits of crystalline limestone have been noted by several workers in the vicinity of Nelson Creek (Crawford, 1894, p. 392; Logan, 1947, p. 259) and southeast of there in sec. 6, T. 23 S., R. 14 E., (Waring and Bradley, 1919, p. 617; Logan, 1947, p. 260), but the deposits have not been described in detail. The deposits are parts of a series of Sur Series carbonate rock outcrops mapped by N. L. Taliaferro (unpublished, but adapted by C. W. Jennings, 1958, in his compilation of the Geologic Map of California, San Luis Obispo sheet). Taliaferro showed these outcrops as a series of faulted masses extending 7 miles southeast from the NW¼ sec. 22, T. 22 S., R. 13 E. to E¼ cor. sec. 8, T. 23 S., R. 14 E. The northwest part of the trend in sec. 22 was examined by this writer in October 1962 and only small, discontinuous outcrops of carbonate rock could be seen, although much float was observed in Nelson Creek and its northeast tributaries. A single traverse made along a northeast tributary in the SE¼ sec. 22, and an adjacent part of sec. 23 revealed only a few small fault slivers or blocks of carbonate rock associated with schistose and granitic rock. These fault segments were interspersed with Franciscan rocks, serpentine, diorite and younger sedimentary rocks. None of the carbonate bodies observed were more than 30 or 40 feet wide and most consisted of blue-gray, medium- to coarsely-crystalline, sheared or brecciated limestone. In addition, crystalline limestone and dolomite of off-white to gray colors were observed as abundant stream float. Two samples of the typical limestone were sampled in place and analyzed by the Division of Mines and Geology, as follows:

Chemical analyses in percent by weight

Sample	Ign. loss	CaO	MgO	SiO_2	Al_2O_3	Fe_2O_3	P_2O_5
No. 1	42.39	49.70	3.08	4.44	.10	.20	.04
No. 2	43.27	54.50	.17	1.03	.11	.23	.04

The most southeasterly carbonate mass mapped by Taliaferro, in sec. 8, also was examined briefly, but the only limestone found occurred as fragments in streams and in late Cenozoic gravels. However, limited carbonate outcrops could be seen to the northwest in SW¼ sec. 5. Farther to the northwest, white marble is reported from sec. 6, (Patriquin deposit) by Waring and Bradley (1919, p. 617), but this was not examined by the author.

Photo 23. Aerial view of Mass Landing facilities of Kaiser Aluminum and Chemical Corporation. The magnesia plant is in center and left-center and the basic refractories plant is at far left. These facilities produce basic refractory materials used by steel and other industries, as well as magnesia products. *Photo courtesy Kaiser Refractories.*

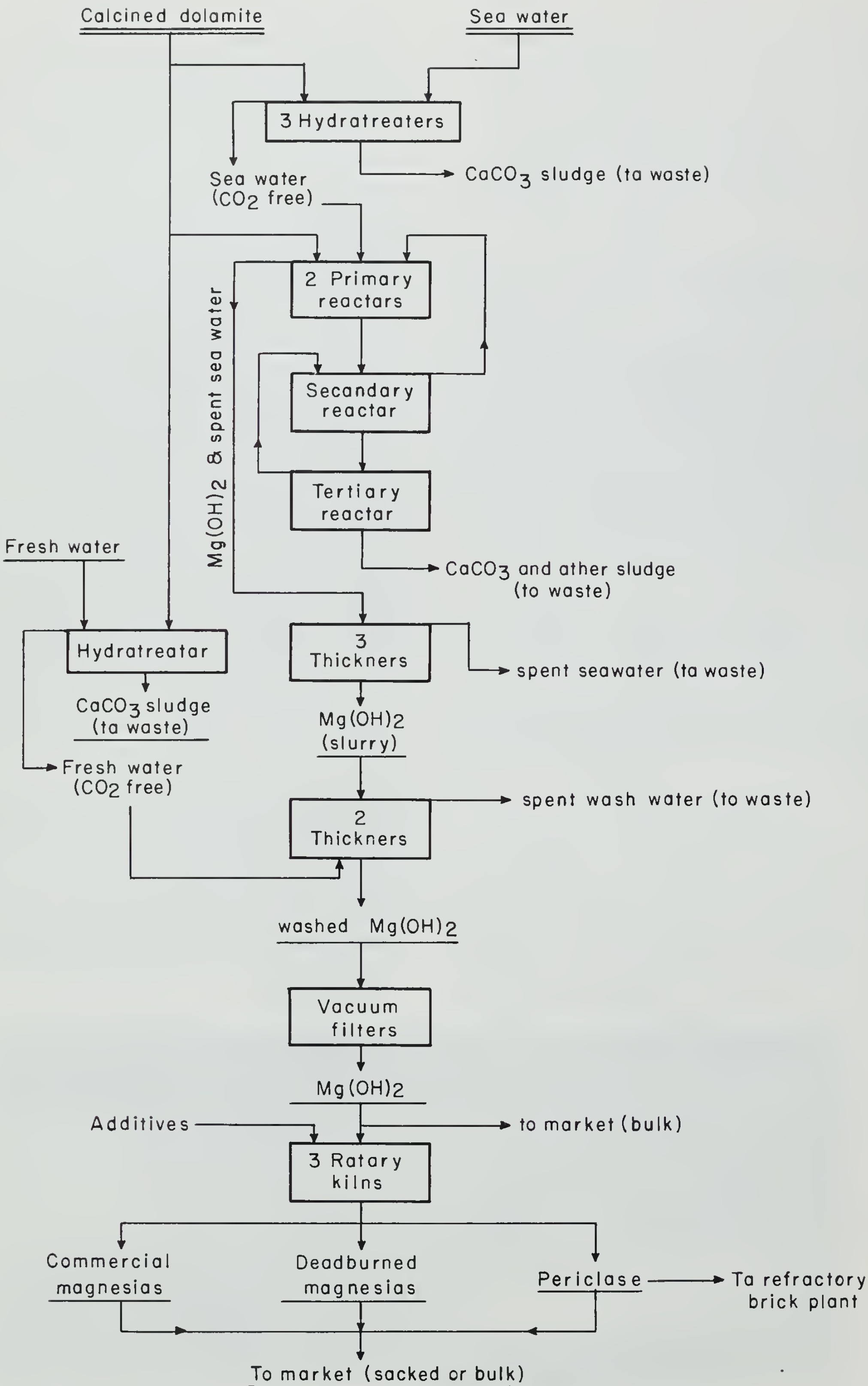

Figure 13. Flow sheet of Moss Landing magnesia plant, Kaiser Aluminum and Chemical Corporation.

Photo 24. Night view of Moss Landing magnesia plant of Kaiser Aluminum and Chemical Corporation as seen across one of the five thickener tanks. *Photo courtesy Kaiser Refractories.*

None of the carbonate deposits observed in secs. 22 and 8 appeared to be of economic size and quality. It is probable that all of the carbonate deposits lying within the San Andreas fault zone are strongly broken by faulting and generally diluted with heterogeneous rock types. Future development is apt to be limited, as the district is remote from present marketing centers and transportation routes.

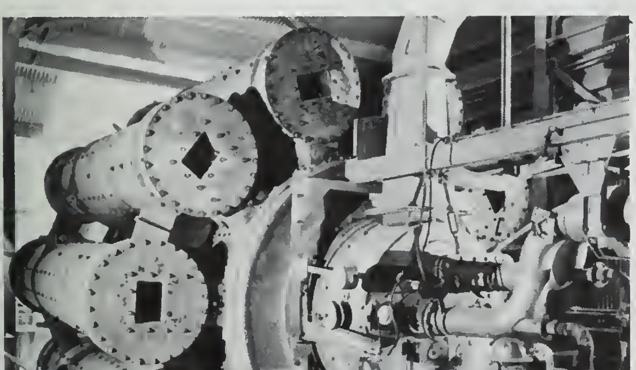

Photo 25. One of three rotary kilns operated by Kaiser Aluminum and Chemical Corporation at its Moss Landing facility. These kilns are used primarily to produce various grades of periclase by calcining magnesium hydroxide, together with certain additives, at high temperature. *Photo courtesy Kaiser Refractories.*

MAGNESITE AND MAGNESIUM COMPOUNDS

The most important ore minerals of magnesium are magnesite ($MgCO_3$) and dolomite ($CaMg(CO_3)_2$). Magnesite deposits of economic interest are not known in Monterey County. Dolomite deposits, on the other hand, have been developed extensively near Natividad and are described in the Limestone and Dolomite section. Magnesium also is found in seawater where its average concentration (equivalent to 0.21% MgO) makes it the second most abundant metal, after sodium. Magnesium has been extracted from seawater at Moss Landing since 1942.

Only three magnesite prospects have been reported from Monterey County and none of these is known to have been produced commercially. These prospects are at the foot of Table Mountain in the southeast part of the county, and are located on small masses of magnesite reportedly in serpentine. At one locality, the magnesite is said to resemble heads of cauliflower and probably is a nodular replacement of serpentine. Development is limited to several shallow pits; one truck-load of magnesite was shipped for testing purposes during World War I. There has been little or no prospecting since that time (also see Tabulation).

Magnesium compounds were first produced at the Moss Landing plant of Kaiser Aluminum and Chemical Corporation (previously Permanente Metals Corporation) in 1942 to provide raw material for their magnesium-metal plant at Permanente, Santa Clara County. After the use of caustic-calcined magnesia for production of metallic magnesium ceased in 1945,

a refractory brick plant was added to the Moss Landing facilities in order to enable the company to provide a wide variety of finished products for use as basic refractories.

Basic raw materials used at the Moss Landing magnesia plant are seawater, pumped from Elkhorn Slough, and caustic calcined dolomite prepared at the Natividad quarry 12 miles away (see Natividad deposit in Limestone and Dolomite section). Approximately 53% of the magnesia produced is derived from seawater, the balance coming from the calcined dolomite. In 1957, the magnesia plant was expanded to handle 30 million gallons of water per day and process 375 tons of magnesia per day (Forbath, 1958, p. 112). The magnesia and refractory brick plants are described briefly below (for more details see Byrns, 1950, p. 150–155, 200–203; Ver Planck, 1957, p. 316, 318; Ceramic News, 1957, p. 48–49; Forbath, 1958, 112–115; Utley, 1959, p. 84–85).

At the magnesia plant, raw seawater is pumped to three 125-foot diameter hydrotreaters where a small proportion of the calcined dolomite is added to remove most of the carbon dioxide from the water. The treated seawater flows simultaneously to two reaction tanks, operated in parallel, and into which is fed a continuous supply of calcined dolomite. The calcined dolomite ($(Ca,Mg)O$) reacts with the water (H_2O) to form a hydroxide of magnesium and calcium ($(Ca,Mg)(OH)_2$). The calcium in the hydroxide is then replaced by magnesium from the seawater to form magnesium hydroxide ($Mg(OH)_2$). The finely-divided magnesium hydroxide overflows the primary reactors and goes to the thickener. The underflow of water and sludge passes in sequence to secondary and tertiary reactors where additional magnesium hydroxide is formed and recycled to the primary reactors. Underflow sludge from the tertiary reactor is wasted.

Thickening takes place in three 250-foot thickeners which are fed simultaneously. The thickened underflow then passes to two similar thickeners, operated in series, where the hydroxide is washed with a countercurrent of fresh water. The product is then pumped to storage for subsequent dewatering by a series of Oliver vacuum filters. After dewatering to 50% solids, some of the magnesium hydroxide filter-cake is shipped in tank cars for use in the paper pulp industry. However, most of the filter cake is calcined in 3 rotary kilns which are similar to those employed at portland cement plants. The kilns are operated at various temperatures as high as 3300° F. and generally small amounts of other materials (volatilized silica, sand, diatomite, iron oxide, fire clay, dolomite dust, and chromite) are added. Most of the hydroxide is calcined to periclase for use in the adjacent refractory brick plant, but some is calcined to deadburned magnesite, and "light" and "hard" burned magnesias. The various products, their definitions and uses are tabulated below:

Product	Definition	Typical use
Not calcined		
Magnesium hydroxide ($Mg(OH)_2$)	Filter cake containing 50 percent solids.	Magnesium bisulphite pulping process.
Calcined		
Magnesias (MgO)	Various grades and water contents according to degree of burning (light and hard burns); no additives.	Chemical processing, sugar, paper, rayon, rubber, insulation, agriculture.
Deadburned magnesite (MgO)	Fully crystallized MgO with various additives.	Refractory grain in open hearth steel furnaces.
Periclase (MgO)	Dense, fully crystallized, with silica added.	Refractory grain mixes and brick manufacture.

Most of the periclase is consumed in the refractory brick plant adjoining the magnesia seawater plant. Here, the main raw materials used are chromite, imported from the Philippine Islands, and periclase. These are crushed, screened, and stored in bins prior to blending of batches in muller-type mixers along with water and various additives. Bricks are formed into more than 2,000 shapes and sizes by mechanical presses under pressures of 12,500 p.s.i. Two types of bonding materials are used in the brick: one, a chemical bond which is hardened by passing the brick through a tunnel drier, and the other, a ceramic bond which sets up only after the brick is fired in a kiln at about 2500° F. Some of the brick is shipped unburned, the ceramic bond developing after the brick is installed. Mixes are also sacked loose, without the addition of water, for use as ramming mixes.

The basic refractory brick and mixes produced by Kaiser will withstand temperatures as high as 3200° F. These products are used by various industries in open hearth and electric steel furnaces, regenerator systems, rotary kilns, copper converters, and reverberatory furnaces. Shipment is by truck, rail, and ocean vessel.

MANGANESE

Several manganese prospects have been developed in the county, but none have been mined commercially. Three of these—the Young (Ross) Ranch, Evans, and Hidden Valley (Wayland) Ranch deposits—plus several lesser prospects occur in chert of the Franciscan Formation. A possible exceptional occurrence is a manganese prospect in SW¼ sec. 9, T. 18 S., R. 7 E. just north of Metz, where August Schmidt, the owner, reports zones up to 30 feet wide and 500 feet long assaying 12-30 percent manganese. The geologic map indicates the Schmidt prospect to lie in granodiorite, but this occurrence has not been verified by the writer. As most of the significant manganese deposits in the Coast Ranges are found in the Franciscan Formation, especially in association with thinly-bedded chert, chances for finding manganese should be most favorable in cherty portions of the Franciscan Formation in the southwestern and extreme eastern parts of the county.

Photo 26. One of three hydroulic presses used to form various types and shapes of basic refractory brick ot Kaiser Aluminum and Chemicol Corporotion's plant at Moss Landing. *Photo caurtesy Koiser Refractories.*

Evans Prospect. Location: SW¼ sec. 24, T. 24 S., R. 6 E., M.D., at an elevation of 1,700 feet on the north side of Devil's Canyon, apparently several miles by trail from the nearest dirt road. Ownership: Not determined (W. J. and J. C. Evans in 1918, probably on government land).

This prospect was not examined by the author, but in 1918, F. S. Hudson (in Trask, 1950, p. 153-154) visited the Evans manganese prospect and described it as follows:

> A consideroble body of chert is present, within which occurs o bed of mongonese ore. The ore bed is exposed for 30 feet olong o strike of N. 70° W. The dip is 65° N. The eostern 15 feet of the bed exposed is 4 to 5 feet wide. To the west the thickness is only o few inches.
>
> All the surface ore is completely oxidized ond oppeors to be o mixture of block oxide ond silico. Porous cores of white silico were seen, from which foct the primory ore moy be supposed to corry consideroble mongonese corbonote. Layers of brown chert corrying spherules of rhodochrosite occur within the ore bed. W. J. Evons reports thot thorough sompling showed the ore to corry 46 percent mongonese. However, o somple token ocross 4 feet of the ore bed, corried 39.8 percent mongonese, 26.5 percent insoluble, ond 1.4 percent iron oxide.

The prospect has not been developed and there is no known production from it.

Hidden Valley (Wayland) Ranch Prospect. Location: E½ sec. 9, T. 22 S., R. 13 E., M.D., approximately 25 miles by road north of San Miguel, the nearest railroad siding. Ownership: Hope Bagby, Hidden Valley Ranch, San Miguel.

The owner reports that one or two manganese prospects were explored north and east of the ranch house, but were not of commercial interest. Another manganese prospect about one mile southeast of the ranch house near the NW¼ corner sec. 15 is developed by a shallow pit, exposing manganiferous chert within a sequence of thinly-bedded, red Franciscan chert. This deposit is small and too low-grade to be commercial, the maximum percentage of manganese being estimated at 10 to 20 percent. F. S. Hudson (in Trask, 1950, p. 154) reported a manganese prospect on the old Wayland Ranch in E½ sec. 9, but this could not be located. Hudson examined other prominent chert outcrops to the northwest, but saw no manganese except for thin films coating fissures in chert.

Young (Ross) Ranch Prospect. Location: SE¼ sec. 32, T. 24 S., R. 6 E., M. D., approximately one mile by private dirt road northeast of State Highway 1. Ownership: Monte Young, P. O. Box 43, San Simeon.

This deposit was known at least as early as World War I when it was owned and apparently prospected to some extent by J. Dutra Ross (present owner says "Russ" is the correct spelling). It is not known when the present owner acquired the property, but in 1954 he leased to a private individual * who mined a small tonnage of manganese ore and shipped it to the Government stockpile at Wenden, Arizona. Although this ore reportedly was accepted, further shipments were tent of the ore.
refused due to the low manganese and high silica con-

When examined in September 1959, the deposit was developed by a small hillside quarry. Bunches or pods of manganese ore were exposed within a sequence of crumpled chert beds that had a general northeast strike. The ore consists of manganese oxide associated with a fine-grained, buff to tan mixture of rhodochrosite, chert, and possibly rhodonite. Only a few thin replacement-fissures and some fragments on the floor of the quarry appeared to be high-grade manganese. The abundance of manganese carbonate (rhodochrosite) and silica indicates that little, if any, high-grade ore might be expected at depth. However, other small deposits of relatively high-grade manganese oxide may exist along the strike of the chert beds. For an earlier description of this deposit see Bradley et al (1918, p. 50–51) or Trask (1950, p. 154).

MERCURY

The most important ore-mineral of mercury is cinnabar, a crimson-red sulfide of mercury. Metacinnabar, a black mercuric sulfide, and native mercury are minor ore minerals found in some deposits. The most significant mercury deposits in the county are located in the Parkfield district in the southeastern corner of Monterey County. The ore in this district was found mainly in serpentine and in silica-carbonate rock formed by the alteration of serpentine. Bailey (1942, p. 143–169) describes the Parkfield district in considerable detail and points out it is divided into two mineralized areas—the Patriquin area and the Table Mountain area—separated by 10 miles of non-mineralized rocks. The Patriquin area lies entirely within Monterey County and includes the important Patriquin mine plus

* The U. S. Bureau of Mines (unpublished) reported WSN Mines (c/o D. C. Nidag, 471 Estero St., Morro Bay) shipped 16 long tons of manganese ore (31 percent manganese) in 1954 from Monterey County to Wenden, Arizona. The ore, which was listed as metallurgical grade oxide ore, was rejected. This shipment is probably from the Young Ranch deposits.

small mines and prospects such as G.W.D., Poppy, Gillette and Sommers deposits. The only important deposits of the Table Mountain area to the southeast are the Kings and Dawson mines which lie in Kings County. The nearby White Mine and Rattlesnake prospect lie in Monterey County but are relatively unimportant.

Aside from the deposits in the Parkfield district, the other mercury deposits are scattered widely in the Santa Lucia Range in the Los Burros, Bryson and Jamesburg areas. The southwestern part of the county west of the Nacimiento fault is underlain by the Franciscan Formation which has been intruded by serpentine and cut by northwest-trending faults. This region offers the basic geologic conditions for mercury deposition. Systematic prospecting around the serpentine masses, especially where serpentine has been altered to silica-carbonate rock, may well reveal additional mercury prospects. Silicified sandstone and other rocks, particularly along regional fault zones, may also be worthy of prospecting. Prospecting outside of the Franciscan Formation probably should be concentrated along fault zones or in the vicinity of recently active volcanic or thermal areas (i.e. hot springs).

Mercury, or quicksilver, is the most important metallic mineral commodity in Monterey County. From 1873 to 1959, production has amounted to 2,045 flasks of mercury worth about $200,000. Probably 90 to 95 percent of this has come from the Patriquin mine. Because the known ore bodies of the Patriquin mine are more or less worked out, the estimated known mercury reserves of the county are believed to be quite small.

Botts deposit. Location: SE¼ sec. 7, T. 24 S., R. 8 E., M.D., on the south side of Sycamore Creek, 4 miles northwest of Bryson and within the Hunter-Liggett Military Reservation. Ownership: Not determined, but was Victor Botts, Paso Robles in 1941.

According to E. B. Eckel, et al. (1941, p. 548, 579–580), the Botts deposit was inactive in June 1940 but was worked intermittently prior to that time. The amount of mercury produced from an 8-pipe retort is undetermined but probably small. There is no indication in official records that the mine has been active since 1940. Development at that time consisted of 10 or more open cuts and crosscut adits from 10 to 100 feet long which explore an area of several hundred square yards through a vertical range of 100 feet. The geology and mineralogy are described by Eckel, et al., as follows:

> The rocks exposed in the vicinity of the mine consist of coarse-grained conglomeratic sondstone ond bituminous shole ond siltstone. All are of late Cretaceous age. The principol structural feoture is o northeostword-trending fault zone, which brings coarse-grained sandstone on its southeost side against shole on the northwest. . . . ot and near the mine the fault zone dips 45° to 80° NW . . . and is from 10 to 50 feet thick. The rocks within it are sheored ond breccioted in voryíng degree.
>
> Cinnabor is widely distributed as scales ond crusts along fractures in the breccia. Crystalline pyrite olso is widespreod, but none wos seen in close ossociotion with cinnabar. Mony pieces of coarsely crystalline white colcite were found in ore piles near the old retort. These contain considerable quantities of cinnabar as grains along cleavage planes and os crystals and groins in vugs. The soil on the hill slope neor the mine ond the streom grovels of Sycamore Creek are known to contain grains and nuggets of neorly pure cinnabar, in places. All indications thus point to the possible presence of o relatively large body of low-grade ore, but this could be proved only by further sampling and explorotion.

Old Murry (Murray, Dutro, Dutra) mine. Location: SE¼ sec. 28, T. 24 S., R. 6 E., M.D., on a southwest tributary to Dutra Creek about 4 miles by jeep road northeast of State Highway 1. Ownership: Monte Young, P. O. Box 43, San Simeon, owns one unpatented claim.

This deposit was probably discovered about 1875 when the Los Burros mining district was created. However, there is no record of development until around 1890 when a small furnace was erected and some quicksilver produced (Crawford, 1894, p. 362). This work apparently was done by a man named Murry who leased the deposit from Frank Dutra. By 1903, the deposit reportedly was developed by a 100-foot shaft and a 40-foot drift which were then caved (Forstner, 1903, p. 124). Apparently no additional work was done until after 1941. Eckel, et al. (1941, p. 548, 577–78) reported that Hearst Sunical Land and Packing Corporation owned the property at that time and verified that it was worked intermittently from 1870 to 1900 with a reported total production of 10 to 15 flasks of mercury.

Monte Young, the present owner, relocated a claim on this deposit in 1944 when the property reverted to public domain after being held for a while as part of a military reservation. Young developed the deposit in 1956 and 1958 by surface methods mainly and obtained 13 tons of ore by blasting and hand sorting. This he crushed to a minus 5-inch size and charged in 500-pound batches to a 2-pipe Rossi-type retort. Production amounted to 2 flasks of mercury, which gives an estimated ore tenor of 0.6 percent or 11.7 pounds of mercury per ton.

The country rocks exposed near the deposit consist mainly of fine-grained sandstone of the Franciscan Formation, cut by a fault or shear zone about 10 feet wide striking N. 80° E. and dipping 60° S. Another smaller fault zone with a north strike and 45° W. dip is truncated to the south by the larger fault. The sandstone within the fault zones has been fractured, sheared, and altered to varying degrees to clay minerals. Both shear zones are silicified and locally veined with calcite.

Cinnabar occurs sparsely in the larger shear zone near the intersection of the north-south fault as disseminated grains and fracture fillings and as scales along shear planes. A small amount of black crystals (probably metacinnabar) and finely divided pyrite are associated with the cinnabar ore. In addition, a green nickeliferous mineral (possible garnierite or mariposite) is found in the ore zone and is generally localized with the calcite veins or along shear planes of altered

rock. The owner considers the green mineral to be an ore guide. Some of the ore is also rust-brown due to oxidation of iron minerals near the surface.

At the time the deposit was visited in September 1959, there was no activity. Development consisted of a 75-foot adit driven to the west and caved within 20 feet of the portal. A shorter adit was reported nearby but this had been covered by surface excavation and is probably caved. Additional bulldozer cuts and an irregular hillside pit have helped to develop the prospect. Little cinnabar was observed at this deposit but additional ore may occur at depth, especially near the intersection of the shear zones.

Patriquin (Pitts, Cholame-Parkfield, Parkfield, Franciscan) mine. Location: NE¼ sec. 2, T. 23 S., R. 14 E., M.D., 4 miles north of Parkfield on the south slope of Mine Mountain; 4 miles by dirt road east of the Parkfield-Coalinga road. Ownership: Fred Harker, 421 Piedmont Ave., Glendale, owns 7 unpatented claims (Cielo No. 1 and No. 2, Cholame, Katy, Patriquin, Silver Diamond, and Serpentine).

The Patriquin mine, the only significant mercury mine in the county, was discovered about 1873 by H. F. Pitts, and others, who reportedly produced about 60 flasks of mercury that year. In 1903, William Forstner reported (p. 123-124) that the mine was developed by an adit driven 924 feet northeasterly and an adit driven 330 feet to the southwest with a 500-foot drift to the northwest. These workings apparently reached a common northwest-trending zone or fault in silica-carbonate rock which showed ore in several places. This development took place near the northwest end of the silica-carbonate mass. Except for the years 1906 and 1908-1910 when a small amount of mercury may have been produced, there is no record of production from 1874 to 1914. However, there probably was periodic development during much of this interval. In 1915, the deposit was re-opened by Louis, A. G., and Mrs. L. S. Patriquin, and J. W. B. Anderson who worked the mine continuously until 1918, producing 1,058 flasks of mercury over the 4-year period. Since 1918 the mine has changed hands several times. Production has been erratic, although substantial at times, including 311 flasks in 1920, and 198 flasks in 1925 (Bailey, 1942, p. 147). The main periods of development since 1915 include 1915-1918, 1920, 1922-1923 (Master Mining Company), 1924-1925 and 1927 (Paloma Mining Co. and Franciscan Mining Co.), 1930, 1934-1940 (various operators), 1943-1944 (Fred Brandes), 1956 (New Patriquin Mining Association), and 1957-1959 (Hackney and Kreider). Production through 1937 is 1,798 flasks according to E. H. Bailey (1942, p. 147). Mercury production since then is less than 200 flasks.

The principal geologic feature is a large northwest-trending lens of serpentine flanked by rocks of the Franciscan formation. An irregular silica-carbonate body, nearly ½-mile long and parallel to the south border of the serpentine lens, has developed under a northeasterly dipping thrust fault in the serpentine. Both the serpentine and silica-carbonate rock are cut by additional, sub-parallel faults that are vertical to northeast-dipping. The cinnabar ore was deposited at several points in the silica-carbonate rock and adjacent serpentine. One of the ore-bodies must have been located at the northwest end of the silica-carbonate mass where most of the early development work took place.

However, the most significant development work at the Patriquin mine has been along the north side (hanging wall) of the southeast half of the silica-carbonate mass. This portion of the mine is described by Bailey (1942, p. 157, 160-161, pl. 17, 18) as follows:

> The cinnabar forms brilliant red crystalline veinlets and encrustations, most of them in fractured silica-carbonate rock but some of them in unsilicified but thoroughly sheared serpentine. There were two main ore-bodies in the mine. . . . One, lying in and beneath a large glory hole at the crest of the serpentine ridge, had a volume of about 50,000 cubic feet; the other, lying to the north at a lower elevation and about 250 feet west of the portal of the main haulageway level, was about a third as large.
>
> . . . both ore bodies occurred beneath a fault that trends northwest and dips northeast. The rock above this fault is sheared serpentine; the rock below is either silica-carbonate rock, locally containing ore, or sheared but otherwise unaltered serpentine.

Bailey considers the ore deposition in the larger ore-body to be localized beneath the main fault at the intersections of several steeper converging faults. This ore averaged about 20 pounds of mercury per ton. Cinnabar deposition that formed the smaller ore-body was controlled by several intersecting faults which underlie the main fault of the Patriquin deposit, Bailey further states:

> Very little ore is believed to remain in the mine. Directly under the glory hole, in very unsafe ground, there is some good ore, which can be expected to yield about one hundred flasks of quicksilver but which probably cannot be gotten out unless the nearly barren overburden is first removed. In the lower ore-body there still remains a little ore that would run 5 pounds of quicksilver to a ton.
>
> As the thrust fault above the silica-carbonate rock has been prospected without result by many tunnels in the vicinity of the main Patriquin mine, little chance remains of discovering any large ore-body at the surface; and to find any small ore-bodies that there may be in the mine would probably require a greater outlay for prospecting than they would repay. Immediately below the thrust fault at depth, lies the best chance of finding additional ore-bodies in the mine. There is no indication that the ore extends to any considerable depth below the present working level; the lowest ore-body in the mine was bottomed, and the downward steepening of the controlling fault is an unfavorable feature.

The Patriquin mine was last worked in 1957, 1958, and the first half of 1959 by Ray Hackney and Fred Kreider (343 N. Central Ave., Glendale) who leased from the present owner. Their work was limited to open pit mining in the vicinity of the large glory hole near the crest of the ridge. After crushing, screening, and washing, they concentrated the ore. According to Fred Kreider (personal communication), the concentrates were retorted in a continuous-flow retort of their own design, which proved very satisfactory. The undeground workings were reported to be in very poor condition at that time.

When visited in April 1960, all of the access shafts and adits in the vicinity of the main workings were caved, except for one adit which probably was the main haulageway. The glory hole area was benched haphazardly and no ore could be seen at the surface. Most of the processing equipment has been dismantled or is in poor condition and none of the retorting equipment remains at the mine. However, several cabins and out-buildings still stand at the campsite east of the mine.

MINERAL WATER

Records show that mineral water has been produced from mineral and thermal springs and wells in Monterey County and sold for drinking purposes from 1896 to 1924. During this period, 400,000 gallons of mineralized water valued at $67,000 was produced at Tassajara Hot Springs, Paraiso Hot Springs and the Monterey Mineral Well. Mineral water obtained at Slate's Hot Springs, Little Sur Hot Springs, and at the sulfur springs on Mission Creek probably have been used to some extent for drinking, but the water is not known to have been bottled or sold commercially. Most of these 6 springs have been developed with facilities for bathing and three (Paraiso, Slate's, Tassajara) were still being operated as resorts in 1961. Three more springs (2 mineral and one thermal) are known along the Monterey coast, but these have not been developed commercially. The nine known mineral and thermal springs are described briefly and referenced in the tabulation at the end of this report.

G. A. Waring (1915, p. 56-62, 215-216, 276) provides the best description and several analyses of the springs. Much of his data is repeated by Waring and Bradley (1919, p. 607-613) and Laizure (1925 p. 44-50). Data on the tonic and therapeutic values of Paraiso Hot Springs is given by Doctors W. Anderson (1892, p. 217-220) and W. E. Fitch (1927, p. 259-260).

MOLYBDENUM

Molybdenite (MoS_2), the most important ore-mineral of molybdenum, is soft, bluish-lead-gray, metallic in luster, and crystallizes in hexagonal plates much like graphite. It has been reported from the Westcott Ranch 8 miles east of Soledad where the mineral is associated with vein quartz in granitic rock. About 1920, Vancouver Pinnacles Molybdenum Company of Aptos prospected a 32-inch wide vein by driving a 50-foot adit, but no production was recorded. Samples were reported to assay as high as 3 percent molybdenum sulfide (Boalich, 1921, p. 156-157, and Laizure, 1925, p. 50). The prospect was not located, but probably is in sec. 26 or 27, T. 17 S., R. 7 E., M.D.

Another molybdenum prospect has been reported near Jackhammer Springs (approximately SW¼ sec. 13, T. 20 S., R. 4 E.) about 7 miles by road south of the end of the paved Arroyo Seco road. Although this prospect was not visited, samples examined by this writer contained considerable amounts of molybdenite and possibly a trace of powellite (calcium molybdate with calcium tungstate) in a garnet-rich tactite formed at a limestone-granite contact. The amount of development is not known, but 16 unpatented claims are reportedly located on the prospect.

OLIVINE

Olivine is a mineral that has been utilized to a limited extent as a refractory material, as a source of magnesium compounds, and more recently as a foundry sand. It is a silicate of magnesium and iron and ranges in composition between two theoretical end-member minerals—forsterite (Mg_2SiO_4) and fayalite (Fe_2SiO_4). Olivine is a common constituent of very basic rocks and is especially abundant in peridotite, an ultrabasic rock. A variety of peridotite composed almost entirely of olivine is known as dunite. Although commercial deposits have not been developed in California, olivine-rich peridotite masses are found in several places and may be of future economic interest.

In Monterey County, a large body of ultrabasic rock at Burro Mountain contains large reserves of olivine-rich peridotite. The core of the mass, covering at least a square mile of area centered at SE cor. sec. 12, T. 24 S., R. 6 E., is largely unaltered peridotite. An alteration rim of serpentine surrounds the core. Based on brief geological examination (Salem J. Rice, 1963, personal communication), the peridotite is estimated to contain 70–85% olivine, plus subordinate enstatite and minor spinel. The olivine is magnesium-rich and approaches forsterite in composition. Variations in rock composition are reported and future exploration may reveal the existence of dunite segregations. The ultrabasic body is of difficult access and lies within Hunter-Liggett Military Reservation.

PEAT

Peat deposits are fairly common northwest of Salinas and are less widespread in the lower courses of Natividad Creek and Canyon del Rey (Figure 14). According to Carpenter and Cosby (1925, p. 72–73, map), who mapped the deposits as part of a soils survey, the peat is predominantly fibrous and spongy, but contains small amounts of fine soil and ash-like products resulting from oxidation of vegetable matter. The peat accumulated in blocked stream drainages under fresh-water conditions and has attained thicknesses generally ranging from 15 to 40 inches, and averaging about 28 inches. The deposits formed from reeds, rushes, tussock grass and other water-loving plants. Blue to gray clay, mottled with iron oxide, underlies the peat. The areas of greatest impurity occur around the margins of the peat deposits and where streams empty into marshy areas.

Although peat deposits have never been developed commercially in Monterey County, some of the deposits may be of sufficient quality and size to be excavated and sold as a soil conditioner. However, these peaty lands may be more valuable as agricultural and hunting lands than as sources of commercial peat.

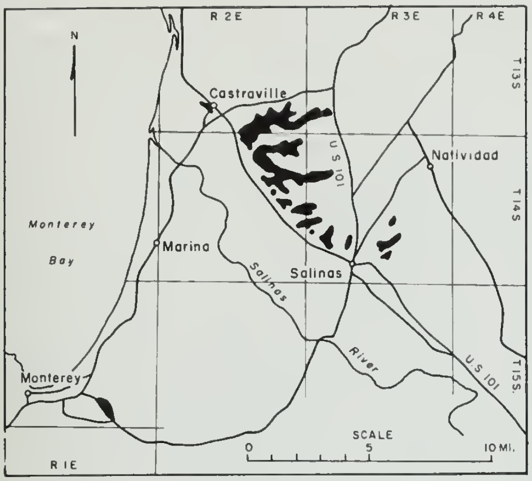

Figure 14. Map showing distribution of peat deposits (dark areas) in Monterey County. (Data after Carpenter and Casby, 1925, map.)

PETROLEUM AND NATURAL GAS

Crude oil and the natural gas associated with it are two of the more important mineral commodities in Monterey County and together account for well over half of the value of total minerals produced. Exploration for petroleum commenced as early as 1888 when the Cholame Valley Oil Co. drilled a well near oil seeps at the foot of Table Mountain. By 1900, bituminous rock outcrops and oil seeps near San Ardo, Bradley, and Lonoak (see under Bituminous Rocks section for description) had prompted exploration, but none of the wells drilled met with commercial success. In spite of this early prospecting, it was not until 1947 that the important San Ardo oil field was discovered. Several smaller oil discoveries have been made since then.

Because of the encouraging oil shows encountered in many wells, good geologic structures, and numerous bituminous outcrops, oil exploration has been more or less persistent over the years. During the 76 years of exploration and development through 1963, at least 400 wildcat wells and core holes were drilled and abandoned and about 1,000 producing wells completed. The majority of the exploratory wells were drilled since 1947 when San Ardo oil field was discovered (Kilkenny, 1963, pp. 55–56). Most of the wells are located in the Salinas Valley along the so-called "San Ardo-Monroe Swell trend" where nearshore sands of the Monterey Formation are well-developed. These sands were deposited over a broad hinge-line or eroded escarpment that divides a shallow relatively stable shelf area to the northeast from a less stable deeper portion of the Salinas basin (Gribi, 1963, pp. 16–27). Sands developed along this hinge-line and adjacent shelf area during Miocene time have been the primary target of exploration programs since the early 1940's and all of the oil produced to date has come from such sands.

The prospects of finding petroleum in the older Tertiary and Cretaceous strata are difficult to assess as relatively few wells have penetrated these formations in the deeper portions of the Salinas basin. Only 3 wells have been drilled to a depth greater than 10,000 feet and all were bottomed in Miocene strata. Rapid lateral changes in lithology and structural complications of the Tertiary formations make geologic interpretations, and hence well locations, difficult. (For a comprehensive discussion of the oil possibilities in the Salinas basin, the reader is referred to the guidebook issued by the American Association of Petroleum Geologists, et al., 1963).

Total production of oil and gas through 1964 in Monterey County is valued at $232,089,061. Oil production has amounted to 145,852,825 barrels, all of which was produced since 1947, mostly from the San Ardo field. The productive oil fields and areas are described below. Natural gas production, with one possible exception, is associated with oil and has come almost entirely from San Ardo. The one exception is the recorded production of gas from 1932 to 1939 by S. D. Gould. The location of this production is not known, but it may have come from Quaternary alluvium near Salinas, where "inflammable gas" was encountered in water wells as early as 1888 (Irelan, 1888, p. 404; Angel, 1890, p. 346–347). Total marketable gas produced through 1964 has amounted to 43,095,914 Mcf (Mcf = 1,000 cubic feet). In addition, an estimated 10 or 11 billion cubic feet of gas has been wasted, mainly because there were no market facilities available during the early oil development at San Ardo.

Oil Fields

King City (San Bernabe) oil field. The King City field is located 5 miles south of King City in secs. 31 and 32, T. 20 S., and sec. 5, T. 21 S., R. 8 E. Richard E. Thorup, operator, discovered the field December 20, 1959, with his well "Thomas Doud Estate" 2, which was drilled in sec. 32 to a total depth of 2,484 feet and encountered oil at an interval of 2,004 to 2,156 feet. Initial production was 76 barrels per day of 16° gravity oil cutting 30% water. A second pool, located to the northwest in sec. 31, was discovered October 2, 1961 by Pennant Operating Company with their well "B. C.B. Kent-Basham" 1-31. That well was completed for an initial daily production of 143 barrels of 16° gravity oil from an interval of 2,417 to 2,455 feet in what is referred to as the Kent-Basham pool. A third pool was discovered three-quarters of a mile north of the Doud pool in January 1963 by J. H. Beach, operator, with his well "Doud" 3-1-32. The well was completed at a depth of 1,860–1,893 feet for 10 barrels per day (net) of 12.6° gravity oil with a 90% cut. Oil accumulations in both the Doud and Kent-Basham pools are in the Thorup sand. By early 1963, eighteen wells had been completed as producers, including one gas well which later yielded oil. One of the wells, the "Thomas Doud Estate" 5, blew out of control January 24, 1961, and spewed oil and gas for 19 hours before being brought under control. No injuries or excessive property damage resulted and the well was eventually completed as an oil producer.

The geology and development of the King City field has been described in detail by H. V. Church (1963, pp. 60–70) and much of the following data is based upon his description. The principal formation exposed or encountered in wells near the field is the Monterey Formation of middle and late Miocene age that may be as much as 3,500 feet thick or more. This overlies lower to middle Miocene shale and sandstone of the Sandholdt and Vaqueros Formations, which may aggregate 1,000 feet thick. Below that is granodiorite basement, possibly with a small interval of Berry Conglomerate (Oligocene). The Monterey Formation is locally overlain by Santa Margarita sandstone (upper Miocene), marine sedimentary strata (Pliocene) and Quaternary dunes, terraces and alluvium. Production is obtained from the Thorup sand in the lower part of the Monterey Formation (Luisian Stage, middle Miocene). In the Doud pool, the Thorup sand has a maximum thickness of at least 320 feet, about 150 feet of which is oil saturated. Porosity reportedly averages 23% and permeabilities are variable, but range as high as 2,100 millidarcies. The Doud and Kent-Basham accumulations lie on a northwest-trending anticline having a gently-dipping northeast flank and steeply dipping southwest limb. At least 3 longitudinal, southwest-dipping reverse faults and minor cross faults complicate the structure.

Total production through 1962 was 297,089 barrels of oil, most of which came from the Doud pool. Gas production is minor. In February 1963, the field was yielding 400 barrels of oil per day from 16 producing wells. Water, produced along with the oil, had increased to an 87.9% cut or 2,916 barrels per day. Although the limits of production have not been established, the oil accumulation appears to be modest and proven acreage at the end of 1962 was 150 acres. The oil reserve, recoverable by primary methods, is estimated to be between 2 and 3 million barrels (Church, 1963, p. 70).

Lynch Canyon oil field. The newest oil field in Monterey County was discovered in September 1962 by Moriqui Exploration Co. when they drilled well "Lanigan" 172 to a total depth of 1,745 feet. The well, located 2 miles northeast of the San Ardo field in SW¼ sec. 24, T. 22 S., R. 10 E., was completed for an initial production of 41 barrels of oil per day (net) of 11.8° gravity oil from the interval 1,706–1,744 feet. During the next month, 3 additional wells were completed at shallow depths in W½ sec. 24.

Oil production is obtained from the Lanigan sand —a coarse, very porous and permeable sand lying at the base of the Monterey Formation of late Miocene age. Overlying the Monterey strata are the Santa Margarita, Pancho Rico, and Paso Robles Formations. The Lanigan sand rests directly on a southwest-sloping nose of a granitic basement high and laps out (shore line edge) to the northeast in NE¼ sec. 24 (Gribi, 1963, p. 72–73).

Production to the end of 1962 totalled 1,460 barrels of oil. Viscosity of the oil is very high and installation of electric bottom hole heaters has increased field production from 47 barrels per day in December 1962 to 110 barrels per day in March or April 1963. Although only 4 wells have been completed and the limits of production only partly defined, Gribi (1963, p. 73) estimates the production area to cover 200 acres.*

Monroe Swell oil field. A minor accumulation of oil was discovered by Texaco, Inc. (then called The Texas Co.), when well "Beedy (NCT-2)" 1 was drilled in SW¼ sec. 19, T. 19 S., R. 7 E. to a total depth of 3,300 feet. The discovery well was completed in June 1949 with an initial production of 30 barrels of 16.9° gravity oil per day and about the same amount of water. Production dropped rapidly and by the end of July, after 370 barrels of oil were produced, the well stood idle before it was finally abandoned in 1951. The well is credited as the discovery well for the field, however. The producing horizon, encountered at depths between 2,220 and 2,435 feet, was named the Beedy zone (pool), which is reported to be late Miocene in age. It occurs near the basal part of the Monterey Formation which overlies continental beds (Berry Conglomerate ?) that rest directly on granitic basement. Accumulation of oil is at the crest of the Monroe Swell anticline, but local closure is believed to be partly stratigraphic. Three exploratory wells were drilled to the northwest, east, and southwest shortly after the discovery but none encountered commercial amounts of oil.

Several years later, subsequent drilling one-quarter of a mile to the north by Bandini Petroleum Company (now Westates Petroleum Co.) revealed the existence of a new pool in the Monroe Swell field. This pool, named the Doud pool, was discovered February 7, 1959, when well "Doud" 54-X was completed for 72 barrels of 19.2° gravity oil per day from a depth of 2,995 to 3,174 feet. Another minor pool was discovered January 6, 1961, when Westates Petroleum Company completed well "Doud" 44 a few hundred feet to the west for 20 to 23 barrels of oil per day cutting 85% water. The new pool was encountered at about 2,000 feet and 230 feet of formation below that depth was opened for production. The "Doud" 44 well also penetrated the top of the Monterey Formation at 1,200 feet and the Doud sand at an interval of 2,748 to 2,954 feet. The Doud zone apparently was not productive in the second well.

The Doud and 44 sands are stratigraphically higher than the Beedy sand. Accumulations in the Doud and 44 sands are due to stratigraphic trapping on the northeast flank of the Monroe Swell anticline (Gribi, 1963, p. 76–77). Total oil production for the Monroe Swell field through 1962 is 39,030 barrels. The 2 Doud wells were producing at a daily rate of 22 barrels of oil and

* For a recent, comprehensive summary of the Lynch Canyon field, see Wilkinson (1965).

12 barrels of water during February 1963. Several unsuccessful wells drilled close to the Monroe Swell field indicate that reserves are small. Proved productive acreage in December 1962 was 20 acres.

Paris Valley oil field. The Paris Valley field is located between the King City and San Ardo fields and lies 3 miles northwest of the town of San Ardo. Since 1926, at least 20 exploratory wells have been drilled within a mile of the present field and several have been completed for minor production, particularly near the W¼ cor. sec. 2, T. 22 S., R. 9 E. The well, "M-A" No. 1, drilled by W. Frank Jones in sec. 2 and completed September 17, 1958 is credited with the discovery of the field. The discovery well was completed at a depth of 684–775 feet in the first Ansberry sand for an initial production of 6 barrels per day of 12.3° gravity oil with 22% water cut. Tidewater Oil Company took over the well later, deepened it to 850 feet, and placed it on production April 6, 1961.

According to Smith (1963, p. 79–81), three oil-bearing sands are found in the Paris Valley field and these are called the first, second and third Ansberry sands. The sands are part of the upper Miocene Monterey Formation which unconformably overlies a thick basal conglomerate. Unconformable overlying units include the Santa Margarita, Pancho Rico, and Paso Robles Formations. Oil accumulation is in a northwest-trending, closed anticline, which shows about 300 feet of closure in the first (upper) Ansberry sand. A well drilled at the crest of the anticline penetrated 98 feet of good oil sand and 17 feet of silty oil sand in the first Ansberry (depth of 665–780 feet), 50 feet of oil sand in the second Ansberry (990–1045 feet), and 15 feet of sand in the third Ansberry (1190–1205 feet).

As the oil in this field is very heavy (11–12° gravity) and viscous, it is quite difficult to produce. Consequently, several efforts have been made to stimulate production by employing bottom hole heaters, hot salt water, and steam. It is reported that Tidewater Oil Co., the present operator, is inaugurating other heating methods to stimulate field production (Gribi, 1963, p. 2; Smith, 1963, p. 81). Total recorded production through February 1963 is 1,101 barrels of oil. From the efforts extended to develop the field—both by drilling and stimulation methods—it is clear that potential oil reserves are substantial.

San Ardo oil field. The San Ardo oil field is located along the Salinas River between San Ardo and Bradley. As of 1962, it was the sixth largest oil producer and contained the eighth largest reserves of all fields in California. Due to its recent discovery in 1947, San Ardo ranks only 25th in total production among the oil fields of the state.

Although petroleum prospecting in the Salinas Valley began prior to 1900, the shallow oil sands at San Ardo were not drilled until 1946. The Texas Company (now Texaco, Inc.) started the first of 3 wells—"Aurignac" Nos. 1, 2, and 2a—in sec. 4, T. 23 S., R. 10 E. Two of these wells (Nos. 1 and 2a) encountered substantial oil and gas showings, but could not be completed due to excessive sand that entered the hole with the heavy oil. The strong oil shows were from the Aurignac sand, which later was commercially developed when the "sanding" problem was overcome. In July 1947, North American Oil Consolidated and Jergens Oil Company drilled a joint test in sec. 34, T. 22 S., R. 10 E. and penetrated 240 feet of sand, of which the top 30 feet was saturated with oil and the rest was wet. These shows led The Texas Company to drill "Lombardi" 1, which was completed on November 4, 1947, as the discovery well of the San Ardo field. The well was located in sec. 27, T. 22 S., R. 10 E. in the Lombardi area at the north end of the field. Initial production was 155 barrels per day of 10° gravity oil from a 25-foot interval (depth 2,133–2,158 feet) of the Lombardi sand (Bradford and Lawrence, 1957, p. 27). The Lombardi area later was considered to be subcommercial due to the small amount of oil and high percentage of water produced.

During the 1½-year period following the initial discovery, exploration to the south and southeast revealed profitable oil accumulations in 3 additional areas—the Campbell, Aurignac, and Superior areas. The Campbell area, discovered July 15, 1948 is the major productive area of the field and includes the productive Lombardi and underlying Aurignac pools. The Aurignac area was discovered December 28, 1948, and is productive only from the Aurignac sand. Although the Aurignac pool in this area is developed on a small anticlinal structure, it is contiguous with the Aurignac pool of the Campbell area and probably should not be considered as a separate pool. Discovery of the Superior area came March 3, 1949, when oil was produced from the Aurignac sand. Here too, the producing horizon probably is contiguous with the Campbell area to the west, but it is still considered, statistically, as a separate area.

Development of the San Ardo field proceeded slowly after mid-1949 when 59 wells had been completed, because the oil was of very low gravity and extremely viscous—hence difficult to produce, transport and sell. Furthermore, pipeline facilities were unavailable and the oil had to be trucked 60 miles to Union Oil Company's pump station at Santa Margarita (Miller, 1953, p. 11). In addition, due to water, gas, and sand that entered the holes along with the oil, initial wells were difficult to complete satisfactorily. Water would cone or channel upward 30 to 50 feet through the oil sand shortly after completion, causing the well to go to water. This problem was controlled by bottoming wells a considerable distance above the oil-water interface. Gas also could cone downward through the oil sand and would cause wells to yield only gas. The downward coning was eliminated by setting casing 20 feet below the gas-oil contact. Early wells also experienced trouble with uncontrollable

sanding, but this was effectively overcome by the use of gravel-packed liners.

In order to facilitate pumping of the viscous oil, a diluent (31°-gravity cutter stock oil) is injected down the producing wells, where it commingles with the crude oil, reducing the viscosity and increasing the gravity. The oil is stored in stock tanks where it is heated to 200° F. Heating greatly assists in separating the oil, gas, and water fractions and permits the crude oil-cutter stock blend to be more readily piped (Petr. Week, 1956, p. 17–18). Prior to installation of pipeline facilities in 1951, about 2,000 barrels of oil were produced daily and this had to be trucked to market. After installation of an 8-inch line from the field to Estero Bay, 40 miles to the south, San Ardo production was developed rapidly to more than 32,000 barrels per day by April 1953. At Estero Bay the crude oil blend is shipped by tankers to Los Angeles for refining. Incoming tankers supply cutter stock for transportation from Estero Bay to San Ardo via a 4-inch pipe line that parallels the main line.

The geologic formations at San Ardo field consist of a relatively thin sequence of marine and nonmarine beds of Tertiary and Quaternary age that rest on granitic rocks of possible Cretaceous age. The sedimentary strata, aggregating some 2,500 feet thick, form a modified, northwest-trending anticline over a broad basement high. Nonmarine, granitic conglomerate and sandstone flanks the southwest margin and locally fills depressions of the granitic high. Unconformably overlying this is the upper Miocene Monterey Formation which has been subdivided into several units by various workers (Kilkenny, et al, 1952; Colvin, 1963, pp. 57–58; and others), as follows (bottom to top): Aurignac sand—250 feet thick; Aurignac siltstone—35–70 feet thick; Lombardi sand—250 feet thick; Lombardi siltstone (including "E" sands)—250–500 feet thick. Marine sandstone and siltstone of the Santa Margarita Formation conformably overlie the Monterey and have a rather uniform thickness of 100–150 feet. The overlying marine Pancho Rico Formation of Pliocene age consists of 1) a lower, diatomaceous siltstone and mudstone unit (300–500 feet thick) and 2) upper sands. The upper unit grades upward into nonmarine gravel, sand, and clay of the Plio-Pleistocene Paso Robles Formation, and together these strata form an undifferentiated sequence 1,200 feet thick. Quaternary stream deposits locally fill present valleys. There is no known faulting in the main part of the field, although upper Miocene strata have been thrust over younger rocks along the southwest-dipping Los Lobos thrust fault in the west part of the field.

All of the oil produced to date has come from the Lombardi, Aurignac and "E" sands of the Monterey Formation. The Lombardi sand is remarkably uniform in thickness and is characterized by highly permeable and porous, well-sorted, nearly unconsolidated sand that varies from fine- to coarse-grained. It is gas-saturated in the highest 20 feet of the anticlinal structure and has a maximum of 230 feet of oil-saturated sand below that (Miller, 1953, p. 12). Productive limits of the Lombardi pool, which trends northwest, are defined by a tilted water table to the northeast and southeast and a "shale-out" of the sand to the northwest and southwest (Bradford and Lawrence, 1957, p. 30; Baldwin, 1950, p. 1983–1985; 1953, p. 10). In the northeastern part of the field, thin "E" sands above the Lombardi sand are oil-saturated and in recent years have been opened to production with the Lombardi zone. As of January 1, 1963, a total of 581 wells had been completed in the Lombardi zone and 86 million barrels of oil and 18,000,000 Mcf of gas produced (Colvin, 1963, p. 59).

The underlying Aurignac sand is somewhat less porous and permeable than the Lombardi sand and is characterized by fine to coarse, friable sand which is locally silty. It has a maximum net oil sand thickness of 200 feet. The productive limits of the Aurignac pool, which trends slightly south of east, are controlled by edgewater to the west, a basement pinch-out to the north, and by a permeability change around much of the rest of the pool. A tilted water table also exists in the Aurignac pool and at least two small gas caps occur in the west and south-central portions of the pool. By January 1, 1963, a total of 274 wells had been completed. Cumulative production from the Aurignac zone amounted to 39 million barrels of oil and 25,000,000 Mcf of gas.

The gravity of oil at San Ardo ranges from 10° to 14° and averages 11° to 12°. According to a 1962 price schedule of Mobil Oil Co., San Ardo crude oil of 11°–11.9° gravity was priced at $1.60 per barrel. At various times during the 4-year period before January 1962, the same gravity oil was priced as much as 40 cents less per barrel.

Production of oil during 1962 amounted to 11,099,568 barrels, of which 7,763,000 was from the Lombardi sand and the rest from the Aurignac sand. Natural gas produced during the same year from the Lombardi and Aurignac horizons was 2,370,000 Mcf and 3,276,000 Mcf, respectively. All of the present production is from the Campbell area. Table 5 shows yearly production figures for oil, gas, and water. Cumulative oil production is 125,040,810 barrels, and gas is 43,635,104 Mcf. Of the natural gas produced, nearly one-fourth was wasted because pipeline and marketing facilities were not available. An attempt to store the gas and possibly increase oil production was initiated July 1955. This effort proved unsatisfactory because of gas-channeling, and the project was abandoned in December 1955 after 321,709 Mcf of gas was injected into the oil zones. However, completion of gas pipelines to King City and Paso Robles has reduced wastage to less than 1% since 1956.

Table 5 shows that, with each succeeding year, ever-increasing amounts of oil field brine (water) were produced along with the oil and in 1962 more water was produced than oil. In 1955, a water injection

Table 5. Production and disposition of oil, natural gas and water (brine) at San Ardo field, 1947–1962 (data from California Division of Oil and Gas, Summary of Operations—California Oil Fields, 1947–1962 issues)

Year	Average number producing wells: Actual and potential	Average number producing wells: Actual	Oil* production (in bbls.)	Natural gas (1,000 cu. ft.): Production (net withdrawal)*	Natural gas (1,000 cu. ft.): Wasted	Natural gas (1,000 cu. ft.): Injected	Water (in barrels): Production	Water (in barrels): Injection: Water disposal	Water (in barrels): Injection: Water flooding
1947	3	1	737	†0	†0	0	29	0	0
1948	22	13	119,572	†7,517	†0	0	18,978	0	0
1949	61	20	480,765	†5,255	†0	0	16,803	0	0
1950	69	22	188,068	†3,710	†0	0	2,456	0	0
1951	161	153	2,745,052	172,817	54,480	0	70,545	0	0
1952	386	333	8,280,661	614,649	313,755	0	184,937	0	0
1953	432	413	11,283,710	1,734,501	676,813	0	503,015	0	0
1954	485	455	11,172,184	5,045,917	3,709,025	0	811,827	0	0
1955	530	516	10,972,221	6,135,603	2,758,610	‡321,709	1,580,122	587,253	0
1956	628	612	11,732,789	5,577,331	895,481	0	2,114,879	1,100,736	523,624
1957	687	675	11,844,658	4,229,296	119,599	0	3,808,532	2,871,619	377,358
1958	704	648	10,864,509	3,314,562	102,452	0	6,084,126	5,014,715	1,696,902
1959	723	668	10,983,153	3,073,803	136,554	0	9,188,703	1,475,052	6,601,370
1960	736	717	11,517,752	3,537,548	161,967	0	11,640,406	7,407,112	5,184,634
1961	775	756	11,741,432	4,536,065	415,241	0	16,917,107	11,456,479	6,282,602
1962	832	811	11,099,568	5,646,530	460,791	0	19,504,153	13,297,055	7,392,215
Totals	--	--	125,040,810	43,635,104	9,804,788	321,709	72,446,618	43,230,021	28,058,705

* These production figures do not necessarily agree with petroleum and natural gas production figures used in Table 2.
† Figures probably are too low.
‡ Gas storage experiment, not successful.

project was initiated in the Lombardi sand to dispose of the water. Injection is believed to be carried out northeast of the field limits. Water flooding also has been done in the same area, probably for purposes of disposal as well as to help maintain field pressures in the Lombardi sand. Further efforts were made to increase the efficiency of production, and hence total reserves, by an experimental underground in-situ combustion project initiated in 1959 (Western Oil and Refining, 1961, p. 22). This experiment is in the Aurignac sand and covers 11 acres of the Superior area. Five wells were involved, including one for injection and 4 for production. Details of this project are not presently available, although the test was still being conducted in late 1962.

As of January 1, 1963, recoverable crude oil reserves were estimated to be 87,018,000 barrels (Stockman, 1960, and other data). Natural gas reserves amounted to 49,025,959 Mcf as of January 1, 1963. Proved acreage was 4,200 acres as of the same date.

(Other references not cited above for the San Ardo field include: Barger and Zulberti, 1949, pp. 15–20; Fackler, 1953, p. 185; Kilkenny, 1948, pp. 2254–2268).

Other Areas

Biaggi area. Tar sands exposed in sec. 13, T. 22 S., R. 9 E. and extending southeast for a distance of 5 miles encouraged oil exploration in the San Ardo area at least as early as 1900. Several wells were located in sec. 12 to the north and most of them encountered heavy oil associated with the tar sands at relatively shallow depths, but none could be completed commercially. Interest in the area was renewed after the 1947 discovery of the San Ardo field to the southeast. Late that same year, Texaco, Inc., drilled well "Biaggi" 1 in the SW¼ sec. 12, T. 22 S., R. 9 E., to a depth of 1,805 feet and apparently encountered oil shows as the well was not abandoned until 1948. A second well, "Biaggi" 2, was drilled a few hundred feet to the east to a depth of 1,159 feet. An oil zone was encountered at an interval of 1,095–1,159 feet and the well was completed on August 9, 1948 for 28 barrels of 15° gravity oil per day cutting a high percentage of water. The productive zone apparently was in upper Miocene sands of the Monterey Formation. During a brief period in 1948, a total of 316 barrels of oil and 205 barrels of water were produced before the well was abandoned as noncommercial in 1949. Subsequent efforts to develop production in this immediate area have been unsuccessful.

Mozzini area. Marport Oil Co. (now King Ardo Oil Co.) made a minor oil discovery near the E¼ cor. sec. 11, T. 20 S., R. 7 E., 3 miles west of King City, with their well "Marport Mozzini" 2. The well was completed in July 1957 at an unknown depth for 5-10 barrels of 10° gravity oil per day after being drilled to a total depth of 3,073 feet. Four other nearby wells drilled by the same company in 1957 and 1959 were abandoned as unsuccessful at total depths of 2,666 to 3,262 feet. Two of the wells reportedly bottomed in basement rocks and 2 in Miocene strata. The latest well "Mozzini-MP" 1, drilled as a northwest offset to the discovery well, penetrated 740 feet of Paso Robles Formation and marine Pliocene beds before encounter-

ing the Monterey Formation. It reportedly bottomed at 2,601 feet in Miocene rocks—probably near the base of the Monterey Formation or below it in continental Miocene beds. According to unpublished data (Weidman, 1958, P1. II), the Monterey Formation has a thin sandy member at the top and a thicker shoreline sand at its base. The lower sands probably were the objective here. There is no official record of production for the Mozzini area and, in all likelihood, the accumulation is minor.

Parkfield area. The earliest exploratory wells drilled in Monterey County were located in the vicinity of Parkfield near the foot of Table Mountain and along Little Cholame Creek. Numerous oil seeps within and east of the San Andreas fault zone stimulated the search for petroleum. However, none of the many wells drilled was able to obtain commercial amounts of oil although several of the wells drilled in sec. 13, T. 23 S., R. 14 E., at the foot of Table Mountain, were said to have produced a few barrels of oil per day at the time of their completion (English and Kew, 1918, p. 249, pl. 28). These wells are located on the northeast flank of a syncline and the geologic sequence probably consists of (from top to bottom) Pliocene to upper Miocene marine strata, lower Miocene Temblor or Vaqueros Formation, and Upper Cretaceous shales overlying Franciscan and serpentine basement rocks. In spite of the presence of petroleum source rocks and permeable sandstones, it is unlikely that a large accumulation of oil exists in the Parkfield area because of severe faulting and folding. The possibility of a significant closure existing in such a structurally complex area is small.

San Antonio River (Pleyto) area. Outcrops of bituminous sandstone in sec. 35, T. 24 S., R. 10 E., prompted exploration for oil near the southern Monterey Cotunty boundary around the turn of the century and afterwards. More than a dozen wells were drilled in this area, several encountering shows of heavy oil and tar sand, but none could be completed for commercial production. The geologic section here is quite thick, and wells have penetrated the following formations: Paso Robles (Plio-Pleistocene), Etchegoin (Pliocene), Santa Margarita (upper Miocene), Monterey (upper and middle Miocene), Sandholt (middle Miocene), and Vaqueros (lower Miocene). The only well to reach basement was Shell Oil Company's "Branch" No. 1, located in sec. 34, T. 24 S., R. 10 E., which reportedly encountered granitic basement rocks directly beneath the Vaqueros Formation. Total depth of the well was 8,994 feet. Depth to basement apparently increases to the northwest as the Texaco, Inc., well "Shell NCT-1" No. 1 in sec. 6, T. 24 S., R. 10 E. was drilled to a depth of 11,997 feet without reaching basement.

PHOSPHATES

Phosphorus, the eleventh most abundant element in the earth's crust, is a constituent of numerous minerals. In its most common forms, it occurs as apatite and related varieties of calcium phosphate. Phosphate deposits can be divided conveniently into two groups—those of magmatic or igneous origin, and those of sedimentary origin. The former group includes apatite as magmatic concentrations, pegmatite dikes, and veins, some of which are minor sources of phosphate. However, no such deposits are known in Monterey County. Much more important are the sedimentary types of phosphate rock, generally termed phosphorite, which are the sources of virtually all of the phosphate produced in the world. In 1959, the United States produced 15.9 million tons of phosphate rock valued at $99.7 million. Most of this production came from Florida, Tennessee and the western phosphate field of Idaho, Montana and Wyoming.

Several sedimentary phosphate occurrences in California have been known for many years, but these were considered too small or low grade to be developed or even significantly prospected. However, the use of phosphates in the fertilizer and chemical industries has increased rapidly. In 1960, California consumed an estimated 126,000 tons of phosphate, which is equivalent to 426,000 tons of phosphate rock containing 31% P_2O_5. Such rock was valued at $7.30 per ton at mines of the western field, but was worth about $15 per ton (including freight charges) at California points (Mero, 1961, p. 10). Considering that freight charges of shipping phosphate ore to California are equivalent to the price of ore at the mine, it is clear that a much lower grade of phosphate rock could be produced economically in California than the 31% average grade reported for most fields in the United States. During the last few years, prospecting activity has increased sharply in California and several leases have been made and some development work done.

Three phosphate-bearing areas are known in Monterey County. Two of these—in Carmel Valley and Reliz Canyon—consist of pellet phosphorite of the Monterey Formation. Another is located near San Lucas and consists of phosphatized shells and pellets in the Pancho Rico Formation. In addition, samples of phosphorite have been dredged from the sea floor around Monterey Bay (Emery and Dietz, 1950, p. 10, pl. 5; Mero, 1961, pp. 1-10). Further exploration will probably reveal other phosphate deposits.*

The recognition of phosphate rock in the field is rather difficult as it is generally found as gray or brown beds or lenses in stratified rocks. Furthermore, outcrops of phosphate rock are not normally prominent. However, phosphorite often contains a little uranium and is mildly radioactive. As a result, certain deposits may be located by radioactive prospecting methods. Phosphate rock can be readily identified in the field by placing a crystal of ammonium molybdate on the rock and adding a drop of nitric acid. The test is sen-

* Additional pellet phosphate occurrences are described briefly in Gower and Madsen (1965, p. 80–82).

sitive and a yellow precipitate will form if the rock is phosphatic.

Carmel Valley area. Phosphorite has been noted in two places just north of the Carmel Valley Road in sec. 29, T. 16 S., R. 2 E. It is exposed as a poorly-defined bed 6 to 8 inches thick in a road cut along a bypassed portion of the old Carmel Valley Road, approximately 800 feet east of Tomasini Canyon. One-half mile to the southeast, a phosphorite bed about one foot thick is exposed along Carmel Valley Road a few hundred feet east of Juan de Matte Canyon. The phosphate beds are interbedded and gradational with siliceous shale of the Monterey Formation. The phosphorite is buff colored and poorly consolidated, and consists of pellets of collophane (hydrous tricalcium phosphate generally containing small amounts of carbonate and fluorine) admixed with detrital grains and a minor amount of siliceous matrix. The pellets are small, averaging .25 to .42 millimeter in diameter. Chemical analyses of the "cleaned" pellets shows 33.11 percent P_2O_5 (Rogers, 1944, p. 415). Field examination shows the phosphorite to be mildly radioactive, probably due to minor amounts of uranium. Although locally of high grade, this deposit is too small to be of commercial significance.

Reliz Canyon area. Thin beds of phosphorite have been reported from the vicinity of Reliz and Vaqueros Canyons since 1927. Recently, geologists of the U.S. Geological Survey have observed pelletal phosphate in Reliz Canyon (Howard D. Gower, Jan. 1963, personal communication). These phosphate beds are reported to be ½ to 5 inches thick and are interbedded with other sedimentary rocks of the Monterey Formation that dip moderately to the northeast. Extending through a stratigraphic thickness of approximately 2,000 feet, the phosphate-bearing section has been traced 7 or 8 miles southeast from Reliz Canyon in NW¼ sec. 13, T. 20 S., R. 6 E. This phosphate-bearing sequence probably includes or is a southeast extension of the oolitic phosphate beds reported by Reed (1927, p. 195), Galliher (1931, p. 266), and Thorup and Kleinpell (1952, Fig. 4). Small phosphate pellets or oolites, composed mainly of collophane, are estimated to comprise 50-60 percent of the individual phosphate beds. Some collophane is also present in the fine-grained interbeds. The percentage of phosphate present over any given interval has not been determined, but it is estimated that phosphate beds may locally comprise at least 10-15 percent of the rock over a given 10-foot thick interval. More exploration is necessary in order to evaluate the economic potential of this widespread occurrence.

San Lucas area. An occurrence of "pebbles and phosphate pellets" in a hard calcareous reef, located along the east line of sec. 15, T. 21 S., R. 9 E., was reported by Bramlette and Daviess (1944). This reef separated underlying coarse sandstone from overlying diatomaceous shale and sandstone of the Pancho Rico Formation. Phosphatized shells also have been noted at this locality (Howard Gower, Jan. 1963, personal communication). In 1961-1962, Nicol Industrial Mineral Corp. (2850 Bay Rd., Redwood City) prospected phosphate-bearing beds in this area and obtained 2-year prospecting permits from the U.S. Government on parcels of 480 acres and 280 acres in T. 21 S., R. 10 E., and 320 acres in T. 20 S., R. 9 E. The permits were subsequently dropped after it was determined that the rock contained less than 1 percent P_2O_5. The company reported that the phosphate was in the form of pellets and phosphatized shell present in diatomaceous rocks (Pancho Rico Formation?).

SALT

Salt (NaCl) has been produced continuously in Monterey County since 1916 when the Monterey Bay Salt Works was established to supply salt to the nearby fish-packing industry. As far as known, no other attempts to produce salt have been made. Although the salt works is well situated with respect to local markets and shipping facilities, compared to other solar evaporation plants in California its yield is probably somewhat lower due to cool summer fogs. Production was relatively constant prior to 1950, but has risen substantially since then. Reduced fishing activity in recent years has caused the major salt market to shift from fish processing to refrigeration, water softening, and ice cream manufacture.

Monterey Bay Salt Works. Location: secs. 7 and 8, T. 13 S., R. 2 E., M.D., just north of Moss Landing. Ownership: D. L. Carpenter, Box 43 A, Moss Landing, owns 800 acres of marsh land north of Elkhorn Slough and east of State Highway 1.

The present owner and operator acquired the company in 1957 from E. C. Vierra. The Vierra brothers, D. C. and E. C., established the salt works in 1916. The early operations have been described by Waring and Bradley (1919, p. 614), Boalich (1921, p. 157), and Laizure (1923, p. 60; 1925, p. 53-54). Because there have been few important changes in operation since the plant was described comprehensively by W. E. Ver Planck (1958, p. 69-72), the Monterey Bay Salt Works is described only briefly below.

When the works was visited in July 1960, the operator had nearly 300 acres of marsh land in production, including an estimated 14 acres of crystallizing ponds. The processing plant, stockpile, warehouse, and crystallizing ponds are situated on the north bank of Elkhorn Slough close to the highway. The concentrating ponds extend nearly a mile to the north and east of the plant (see Figure 15).

Raw seawater is obtained from Elkhorn Slough by means of an automatically controlled pump having a capacity of 1,500 gallons per minute. The water flows by gravity from the intake pump through a system of 5 concentrating ponds. The flow is controlled by gates between the ponds. When brine in pond 1 attains a salinity of 25 degrees salometer it is

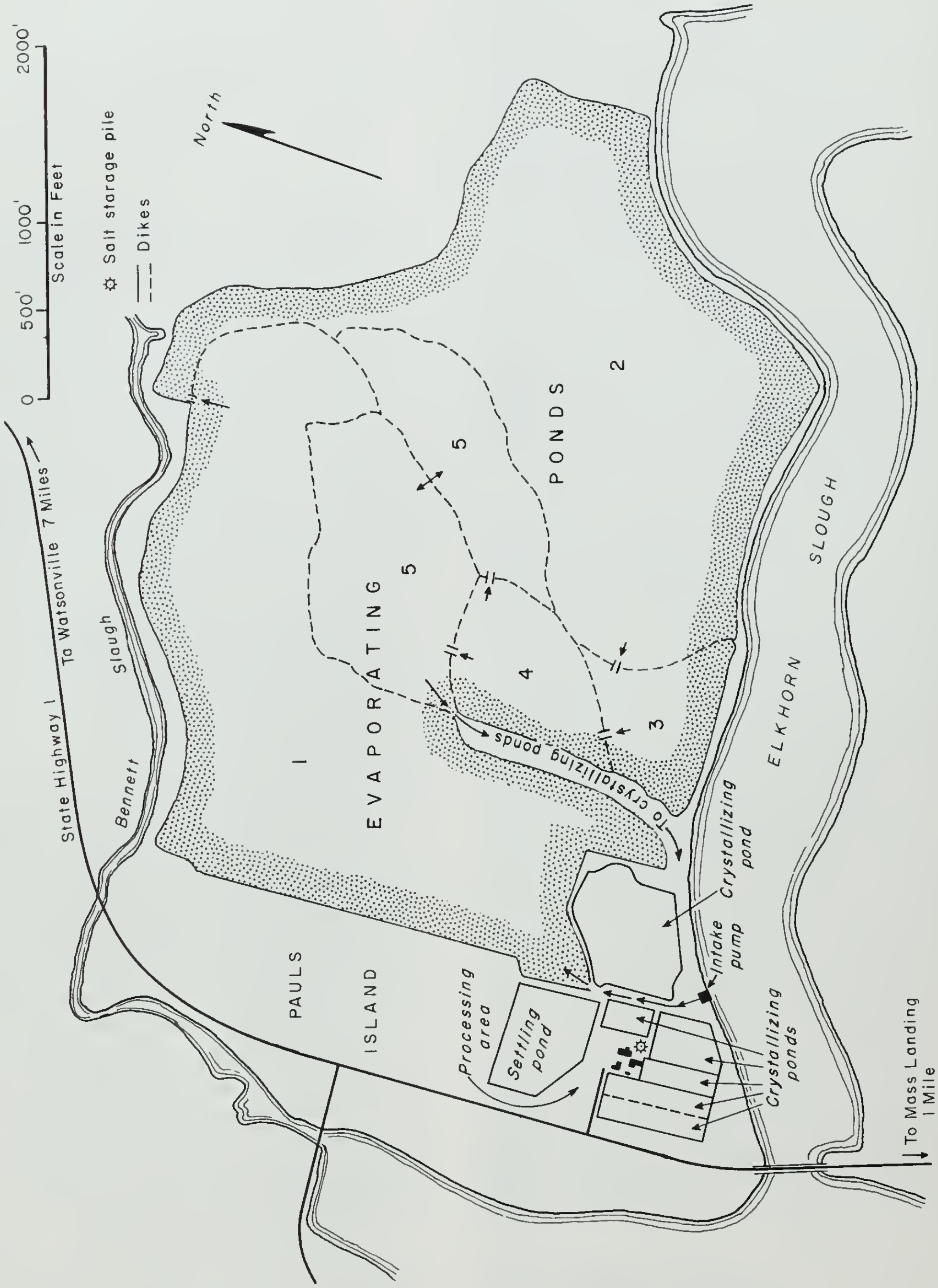

Figure 15. Map showing the evaporating and crystallizing pond system of Monterey Bay Salt Works, Moss Landing.

transferred to pond 2. At 60 to 65 degrees salometer it goes to pond 3 and at 90 degrees to pond 4, the lime pond. Gypsum precipitates in the lime pond and has formed a one-to two-inch thick layer. The brine is then evaporated to saturation at two inter-connected pickle ponds, number 5.

After saturation has been reached, the brine or "pickle" flows through a ditch to the pickle pump. The pump distributes the pickle to a system of small ditches and flumes for filling the crystallizing ponds. Most of the ponds are interconnected so that pickle can be transferred from one to another. A layer of salt averaging 3 inches thick forms in each of the ponds by harvest time. At that time, bittern from the first few ponds is returned to the concentrating pond system and that from the last pond is wasted into Elkhorn Slough. Sometimes crystals of epsomite ($MgSO_4.7H_2O$) form in the last pond (Ver Planck, 1958, p. 71).

The salt is normally harvested from September 1 to December 1. Harvesting is accomplished by shoveling the salt onto a drag chain conveyor which carries it to a 40-foot trough. Saturated brine from a nearby settling pond is piped to the trough and the salt and brine are pumped as a slurry to the processing plant. As the operation proceeds, the drag chain conveyor is moved forward along the 40-foot trough by means of a clutch-operated winch. Every 40 feet the operation is stopped and the drag chain, trough, pump, and engine are advanced. A crew of 13 men can harvest 200 tons of salt per day with this equipment.

Most of the washing is accomplished by turbulency in the pipeline as the salt and brine move to the plant. Here, the pipeline discharges into a 3-foot by 4-foot steel cylinder classifier where brine and dirt overflow and are discharged to the settling pond. A bucket elevator raises the salt from the classifier to a draining trough or screen. Salt is conveyed up the trough by a drag chain and is washed with a spray of concentrated brine (107 degrees salometer) and then a spray of fresh water. The brine wash and 80 feet of additional drain trough were added in 1960. The processed salt is next conveyed to a stockpile. Fine salt that passes the draining trough is recovered and sold as cattle salt.

Salt from the stockpile is reclaimed as necessary and ground by corrugated rolls housed in an adjacent warehouse. The product is sold either in bulk or is sacked in 100-pound paper or burlap bags. The salt is sold locally and used mainly in refrigerator cars, water softening and ice cream plants. The owner plans to install a 4-foot by 20-foot rotary kiln in order to market dried salt for water softening and other uses he is not now able to supply. The plant formerly included a steam drier which dried salt for the fish canneries, but it was destroyed by fire in 1945.

Photo 27. View to southeast of Recent beach and dune sands between mouth of Little Sur River (left center) and Point Sur (far right). Note the "climbing" dunes in center. These dune and beach deposits are probably too small to be of commercial value, except for local purposes. *Photo by Mary Hill.*

SAND AND GRAVEL

Sand and gravel (including specialty sands) together form the third most important mineral commodity group in Monterey County. From 1901 to 1964, recorded production totals close to $50,000,000. The value of sand and gravel produced in each year since 1945 has exceeded one million dollars. These statistics are not entirely reflected in Table 2, because sand and gravel production is included with "miscellaneous stone" prior to 1946. Also, separate figures were kept for glass sand (or silica sand) prior to 1956, and for feldspar since 1952. In spite of the statistical methods used in the past, all of the sand and gravel deposits, regardless of use, are included in this section.

Generally speaking, sand and gravel can be arbitrarily classified according to whether the material is used for construction or for special purposes. In Monterey County, sand and gravel are used in construction as 1) aggregate for portland cement concrete, asphalt concrete, mortar, plaster and stucco; 2) base materials in road construction; and 3) fill and structural backfill. Specialty sand is used for sand-blasting and filtration, in glass and ceramics manufacture, and as foundry and engine sands. A minor amount of specialty gravel (granules) is used for roofing and landscaping and in aquariums.

Much of the sand and practically all of the gravel used in construction comes from Quaternary stream deposits. Specialty sands and granules, on the other hand, are obtained almost entirely from Quaternary beach and dune deposits. The latter deposits also are important sources of construction sand. A small amount of road construction material has been obtained from older formations of sand and gravel.

In order to emphasize the future potential of these materials, the sand and gravel deposits are described below under 3 subsections based on the different types of source materials: Quaternary Beach and Dune Deposits, Quaternary Stream Deposits, and Older Formations.

Quaternary Beach and Dune Deposits

Beach and dune sand deposits of Quaternary age are relatively extensive in Monterey County and are found bordering Monterey Bay, Monterey Peninsula, Carmel Bay, and the Point Sur area. Dune sand also is found in the vicinity of San Lucas. Recent dunes and modern and older beaches bordering Monterey Bay, and Recent dunes of western Monterey Peninsula constitute some of the most important deposits of specialty and construction sands in California. An older sand deposit, partly of dune origin, has been developed on Monterey Peninsula in recent years as a potential source of specialty sand. These beach and dune deposits are described in detail below under Monterey Bay Area and Monterey Peninsula Area.

Other Quaternary beach and dune deposits, either undeveloped or of minor commercial importance, are briefly described as follows:

Carmel Bay area. Recent beach and dune deposits near Carmel and the mouth of San Jose Creek provided sand for glass manufacture, filtration, and other purposes in the past (see Carmel Development Company and Monterey Sand Company—San Jose Creek in Tabulation). Residential and recreational development probably preclude further development of these deposits.

South Coastal area. Recent beach and dune deposits of moderate size exist near the mouth of Little Sur River and at Point Sur. Small, modern beaches also are found at several other points along the coast. Because of their remote locations, small size, and heterogeneous compositions, it is unlikely these deposits will be developed for anything except local construction purposes.

Fort Ord area. Pleistocene sand dunes flank the Recent sand dunes of Monterey Bay for a distance of 10 miles and extend inland as much as 5½ miles, covering 35 square miles of area. According to O. E. Bowen (personal communication, 1962), the dunes average less than 40 feet thick. In spite of the extent of the deposit, it probably is of limited economic value as the sand is somewhat weathered. Also, most of the deposit lies within the Fort Ord Military Reservation.

San Lucas area. Several large dune deposits of Pleistocene age are found north and west of San Lucas on both sides of the Salinas River (R. M. Weidman, 1958, unpublished). The largest deposit is 5½ miles long and averages 1½ miles wide, but the thickness is not known. One sample examined by this writer was a moderately well-sorted fine- to medium-grained sand containing a substantial amount of silt. Quartz and subordinate feldspars constitute about 85 to 90 percent of the sample, but rock fragments, micas, trash and heavy minerals were notably evident. If the sample is representative, it is unlikely the deposits could be developed for special uses as the grains are dull, frosted (pitted), and stained, the feldspars are decomposed, the sand is not well-sorted and a large amount of waste material (fine sand, silt, clay, rock fragments, etc.) is present.

Monterey Bay Area

Quaternary sand dunes rim most of Monterey Bay from Sunset Beach in Santa Cruz County to the City of Monterey (see Map, Plate I). The youngest of these dunes (Recent age) contain relatively unweathered sand, so are useful for specialty and construction purposes. They lie immediately adjacent to the beach, reach inland a maximum of one-half mile, extend continuously from the Salinas River to Monterey, and attain a maximum elevation of 169 feet. Sparse vegetation and lack of soil development allow the Recent dunes to be easily differentiated from the older dunes nearby. Except where disturbed by man, the dunes appear to be more or less stabilized. In general, the

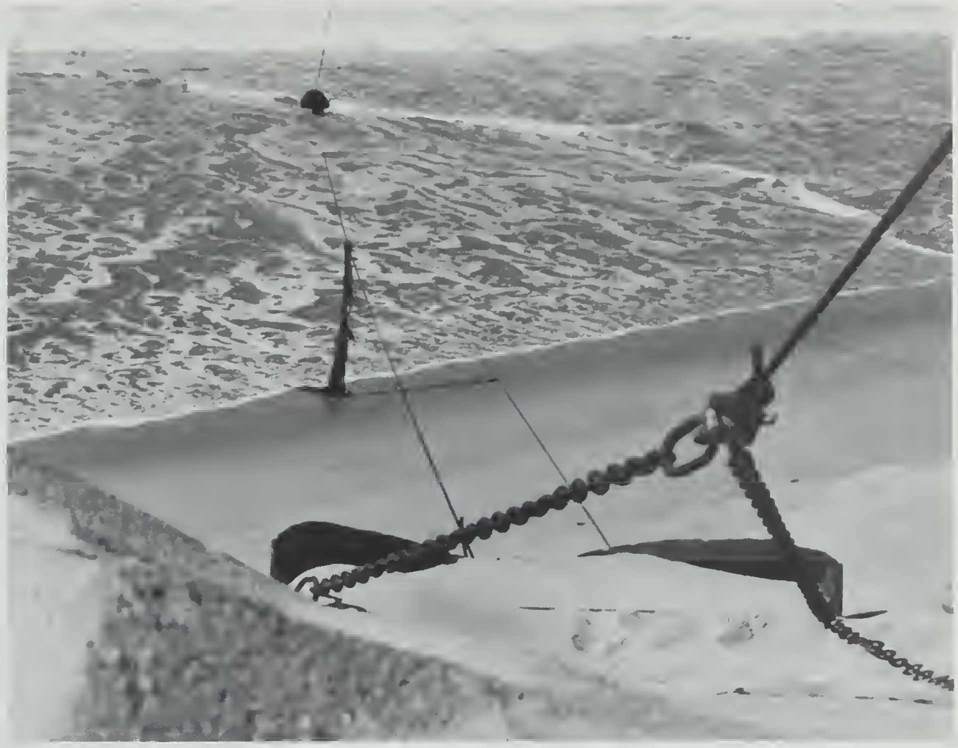

Photo 28. Modern beach sand along the southern shore of Monterey Bay is dredged by dragline scrapers at five separate points by four companies. This coarse, well-sorted sand is an important source of sand blasting sand, plaster sand, and fine aggregate used in asphalt and portland cement concretes.

sands are medium-grained, and well-sorted, although there are variations from one dune to another, and even within individual dunes. The coarsest dune sand is located in the vicinity of Fort Ord, the average grain size progressively diminishing both to the north and south (Galliher, 1932, p. 55). The sand grains are subangular to subrounded, being more angular in the finer sizes. Most of the grains are somewhat coated with iron oxide and other materials, which masks their polish and luster. Little frosting (pitting) was noted on the grains. The sand consists predominantly of quartz and feldspar, with lesser amounts of granitic and other rock fragments and minor amounts of biotite, shells, heavy materials, and organic debris. The dune sand deposits are worked in 5 or 6 places for use as engine, foundry and other specialty sand purposes, as aggregate in portland cement and asphalt concretes, and as fill. Dune sand reserves along Monterey Bay are very large, relative to current demands, and the main threat to future supplies would seem to be erosion and the cultural developments of man (land subdivision, highways, etc.).

Modern beaches border the eastern margin of Monterey Bay for a distance of more than 30 miles and are interrupted only by the channels of Elkhorn Slough and Pajaro River. The sand sizes and compositions of these beaches vary considerably with location and, consequently, not all of the sand is of commercial interest. Only those beaches containing coarse sand have been mined; beaches composed of medium and fine sand are not considered practical sources of construction sand. Coarse beach sands extend continuously from Seaside northward to a point about 2 miles south of Elkhorn Slough (Galliher, 1932, map and p. 71) and are bordered on the east by sand dunes that lie just above the high tide line. To the north and south, the coarse sand progressively grades to medium and fine beach sand. The coarsest sand tends to be deposited in the vicinity of Fort Ord; north and south of here the sand becomes progressively finer (Galliher, 1932, pp. 54–55). Because wave activity varies continually, the average grain size at any given beach changes from time to time, especially with the seasons. For this reason, beach sand is generally coarsest during the stormy seasons, becoming finer during the summer and fall, frequently causing sand operators to suspend dredging operations.

The coarse beach sand is composed of quartz, feldspar, and granitic fragments, with small amounts of other rock fragments (e.g., chert, siliceous shale, metamorphic rocks) and minor amounts of shells, biotite, heavy minerals and trash. Slight variations in composition exist, depending on local conditions. The sand is predominantly polished and subrounded in the coarse sizes, becoming subangular in the subordinate medium-sized grains. Most grains are iron-stained, giving the sand an overall buff color.

In addition to modern beach deposits, somewhat older deposits of coarse sand underlie the sand dunes near Lapis, and at Sand City (near Seaside). These deposits probably represent older beach deposits left when Monterey Bay occupied a slightly more easterly position than at present. If so, the older beach deposits very likely are contiguous with the modern beaches; therefore, older beach sands may be relatively extensive and of considerable economic interest in the

future. The mineralogy and commercial uses of the older beach sands are similar to those of the nearby modern beach sands. Two deposits have been worked commercially: the Sand City deposit (Monterey Sand Company) prior to 1960 and the Lapis deposit (Pacific Cement and Aggregates, Inc.) as recently as 1962.

In 1962, four companies were working 5 modern beach deposits and one older beach deposit. Most of them also utilize dune sand, in lesser amounts, along with beach sand. The coarse beach sand is used mainly for aggregate in plaster, concrete, and asphalt paving and as sandblasting sand. Small amounts are used as filter sand, roofing granules, aquarium granules and other specialty purposes. Modern beach sand reserves continually vary and therefore are difficult to determine. Because of erosion and deposition, the beaches are generally retreating (eroding) or advancing (building) but are almost never stable. Such instability can, and does, create problems for the sand producers, especially with reference to the location of dragline and processing equipment. In recent years, several operators reported that the beaches were retreating. The Beach Erosion Board, U. S. Army Corps of Engineers, considers shore erosion in the Fort Ord vicinity to be severe and currently is studying the situation to determine the causes of erosion (Personal communication, Jack Stirton, Chief, Beach Erosion Board, San Francisco, 1961).

The deposits and companies active in 1962 are described below. Earlier activities are summarized in the tabulation.

Granite Construction Company deposit. Location: SW¼ sec. 15 (proj.), T. 15 S., R. 1 E., M.D., ¼ mile west of State Hwy. 1 and adjacent to the beach in Sand City. Ownership: Granite Construction Company, Watsonville.

Recent beach and dune sands have been excavated by Granite Construction Company since the late 1940's, as a source of fine aggregate for use in their concrete and asphalt batch plants. The coarse beach sand is dredged from the surf zone by dragline and moved to a surge pile adjacent to the beach. Medium- and fine-grained sand is obtained, also by dragline scraper, from the windward side of a nearby dune and stored at a separate surge pile. Sand from the surge piles is conveyed to a vibrating 4-mesh screen where oversize gravel and trash are scalped and wasted. The sand is then stored in elevated bins for later trucking to the concrete and asphalt batch plants located about one-quarter of a mile to the east. The dune and beach sands are generally blended on the conveyor prior to screening, but either may be processed separately. The sand is not washed.

Screen analyses made by this writer of the unwashed beach and dune sands sampled July 13, 1960, at the surge piles, are tabulated below:

Photo 29. Granite Construction Company sand plant at Sand City processes coarse beach sand and some dune sand for use as asphalt and concrete aggregate. Sand is screened but not washed.

Beach sand		*Dune sand*	
U.S. sieve size	*Percent sand retained*	*U.S. sieve size*	*Percent sand retained*
4	Tr.	10	0.0
10	14.1	20	2.9
20	66.6	30	5.7
30	11.1	50	44.6
50	7.2	80	34.7
80	0.8	100	7.3
—80	Tr.	140	4.1
		—140	0.7

The beach sand is coarse to very coarse (median diameter 1.1 mm.) and very well sorted, (quartile sorting coefficient 1.25) with most of the grains being subrounded and polished. However, the medium-sized grains tend to be subangular. The dune sand is medium-grained (median diameter 0.3 mm.) and well sorted (sorting coefficient 1.35) with the grains generally being subangular, dull, and only slightly pitted. Quartz, feldspar, and granitic (composite quartz-feldspar) fragments make up more than 90 percent of both the beach and dune deposits. Various rock fragments, and smaller amounts of biotite, heavy mineral, shells, glass, and organic trash constitute the balance of the sand.

The company estimates (L. S. Hawkins, Personal communication, 1960) about 85 percent of sand is used as an aggregate in their concrete batch plant, most of the rest of the production going to the asphalt batch plant. Plant capacity is not definitely known to the author, but is estimated to be roughly in the order of 100 tons per hour. When visited in July 1960, the plant

reportedly was being operated an average of 2 days per week. Coarse aggregate for the batch plants is purchased at Logan Siding (crushed hornblende diorite) and Hollister (gravel), both in San Benito County. Waste fines (minus 80-mesh) imported from Ideal Cement Co., San Juan Bautista, are blended with the sands to round out the grading of the sand aggregate used in concrete.

Monterey Sand Company—Marina deposit. Location: Center sec. 24 (proj.), T. 14 S., R. 1 E., M.D., approximately one mile northwest of Marina. Ownership: Monterey Sand Company, Box 928, Monterey.

This beach sand deposit reportedly was developed around 1944 by Monterey Sand Company. The sand is coarse and well sorted, being similar to other beach sand between Sand City and Marina. As at most other sand plants located along Monterey Bay, the sand is excavated from the surf zone by dragline scraper and onto a surge pile. From there it is reclaimed and conveyed to the washing-screening tower where it is washed over a ⅜-inch mesh screen with fresh well water, the oversize gravel and trash being wasted. Water and sand are fed to primary and secondary hydraulic classifiers (funnel type) where the coarsest material is separated and stored in a drain bin. The rest of the sand overflows to a dewatering device (tank with inclined, segmented "sand wheel") where the plaster sand fraction is removed and stored in another drain bin. Fine sediment and trash from the primary classifier and the dewaterer are carried with the overflow water to a nearby settling pond where the fines are wasted. Although as many as 8 sand fractions (size ranges) reportedly can be separated by the above processes, only two fractions—coarse (for sandblasting sand) and fine (for plaster sand)—were being segregated in July 1960. Some of the plaster sand is sold wet in bulk and some is trucked, along with the coarse sand, to the drying-screening plant, one-quarter mile to the east, for further processing. Plant foreman, Gene Meyers (personal communication, 1960), states that recent recession of the coastline has caused the company to relocate their dragline, surge pile, underground hopper and conveying system to a more inland location.

At the drying-screening plant, sand is dried in a gas-fired rotary drier and then screened to 9 basic sizes, ranging from one-quarter inch down to minus 30 mesh. Each size is stored separately in bins and recombined as desired on a blending belt below. Sandblasting sand, stucco sand, engine sand, and filter sand, and aquarium and roofing granules produced here are the same as produced at Monterey Sand Company's processing plant in Sand City. Products from the Marina plant are shipped in bulk only, by truck or rail. The nearest railroad siding is at Marina about one mile away.

Monterey Sand Company—Sand City deposit. Location: SW¼ sec. 15 (proj.), T. 15 S., R. 1 E., M.D., 2,000 feet west of Del Monte Ave.-Fremont St. (State Hwy. 1) intersection, in Sand City. Ownership: Monterey Sand Company, Box 928, Monterey.

The Sand City deposit is one of 2 major sand deposits operated along Monterey Bay by Monterey Sand Company (the other is at Marina and is discussed above). This beach and dune sand deposit was developed at least as early as 1931 by Sydney Ruthven

Photo 30. Screening-blending section of Monterey Sand Company's Marina plant. Both beach and dune sands are utilized here. Note extensive development of Recent, partly stabilized sand dunes. Small, ephemeral lake (now dry) is a common feature near Marina.

(1931–1941) and possibly earlier by others. Monterey Sand Company owner R. E. MacDonald reports his company's Sand City (Seaside) operation began in 1946. Here, coarse beach sand is obtained from the surf zone by dragline scraper and moved a short distance inland to the surge pile. An underground hopper feeds the sand to a conveying belt and thence to the washing-classifying section nearby. This preliminary section was relocated after a storm during the 1959–60 winter caused the beach to retreat 40 feet (personal communication, Blair MacDonald, Monterey Sand Co., 1960).

At the washing-classifying section, the sand is washed with fresh well water over a ½-inch or ⅜-inch screen where oversize gravel and trash are wasted. The under-size goes to a unique hydraulic classifier, consisting of a compartmented, rectangular tank employing a "hindered settling" principle to classify the sand. The tank is partitioned lengthwise into 3 compartments, the two outer compartments being further subdivided. Water and sand flow into the central compartment where much of the coarser sand settles. The coarse material is lifted out of the compartment by buckets attached to a large rotating "sand wheel" and dropped into storage bins below to await further processing. Sand and water from the central compartment overflows into the subdivided flanking compartments where 3 additional fractions can be obtained by introducing water into each sub-compartment to hinder settling. However, when visited in July 1960, all of the material not removed by the "sand wheel" went to a dewaterer, which consists of a tank with an inclined sand wheel. The silt and very fine sand, along with the water, overflows the tank and goes to a settling pond to be wasted. The sand that settles is lifted out of the tank by a sand wheel and conveyed to a nearby storage area for use as a plaster sand or for blending.

Medium-grained dune sand, obtained nearby, apparently is processed solely to remove trash and conveyed directly to the storage area. Ground sand from Del Monte Properties Company and fine gravel (¼ x ⅛-inch granules) from Hollister are also stockpiled there. By means of hoppers, these 4 basic materials are fed to an underground belt where they are blended as desired to make 4 main products: plaster sand (unblended), dune sand (unblended), concrete sand (blend of plaster and dune sands), and "State" (Division of Highways) specification sand for concrete (blend of plaster, dune, and ground sands, and fine gravel). These products are stored in 6 bins for bulk shipment by truck. Capacity of the beach plant is reported to be about 80 tons/8 hour day. Two men are employed and the plant operates an average of 5 days a week. The coarse sand fraction from the hydraulic classifier is trucked about one mile to the drying-screening plant to the south.

In addition to their present beach and dune sand operation, Monterey Sand Company operated a pit in coarse sand several years ago near the Southern Pacific Railroad tracks one-quarter of a mile southeast of their beach plant. This pit is located at a low elevation and probably was developed in older Quaternary beach sand below the base of Recent sand dunes.

The drying-screening plant for the Sand City operation is situated at Clementina and 6th Streets, adjacent to a railroad siding just outside of Seaside. The head office of the company is located adjacent to the plant. Materials processed here consist mainly of the coarse sand fraction produced at the Sand City beach plant. A little material also comes from their Marina plant and possibly from their Odello deposit (a small development operated infrequently to obtain gravel and coarse sand from the Carmel River—see below under Quaternary Stream Deposits). All sand processed here is transported by trucks which dump into an underground hopper. A bucket elevater moves the sand to a gas-fired, 5-foot by 40-foot rotary drier. The dried sand is conveyed to the screening section where a series of vibrating screens segregate it into 9 basic sizes ranging from ¼-inch to minus 30 mesh. The sized sand is stored in large bins for later blending and shipment. Blending is accomplished on an underground conveying belt, and the company is able to produce a wide variety of sandblasting, stucco, engine, and filter sands, as well as aquarium and roofing granules. Sand for sandblasting is the most abundant product. The end products are conveyed to an adjacent building for sacking and bulk loading for shipment by truck or rail.

Surplus sand from the Sand City beach plant and surplus sand fractions from the screening section are trucked to a large, open stockpile for later reclaiming. The stockpile is located about 1,000 feet east of the Sand City beach plant.

Pacific Cement and Aggregates, Inc.—Lapis deposit. Location: E½ sec. 13 (proj.), T. 14 S., R. 1 E., M.D., ½ mile west of Lapis Siding and 2 miles north of Marina. Ownership: Pacific Cement and Aggregates, Inc., 400 Alabama Street, San Francisco, owns 400 acres.

Beach and dune sands near Lapis have been produced since about 1906 by E. B. and A. L. Stone (1906–1918), Bay Development Company (1918–1928), and Pacific Cement and Aggregates, Inc. (formerly Pacific Coast Aggregates) (1929–present). In the early years, beach and dune sand was obtained by dragline or crane and loaded into railroad cars with little or no processing. More recently, the beach sand was washed, screened, and sometimes dried prior to shipment. Previous production included aggregate sand for concrete and mortar and specialty sand for sandblasting, foundries, marble cutting, and locomotives (track sanding). Some of the early operations are described by Waring and Bradley (1919, p. 614–615), Laizure (1925, p. 55), Sampson and Tucker (1931, p. 441), and Wright (1948, p. 45–46).

About 1959, Pacific Cement and Aggregates, Inc. ceased utilizing the modern beach and Recent dune

Photo 31. Dredging pond at Pacific Cement and Aggregates' Lapis deposit. Here, older beach sands lie below Recent dune sand deposit. The high water table permits sand to be dredged economically from a pond.

Photo 32. Pacific Cement and Aggregates' classifying section at Lapis. Here, coarse sand is classified in a "jet sizer," employing hindered settling principles. Main products are plaster and sand-blasting sand.

deposits and began using coarse sand from an older beach deposit buried beneath the dunes about ¼ mile inland from the present beach. Because ground water is relatively abundant and lies at a shallow depth, the company was able to develop a pond and employ a suction dredge. When the sand plant was visited in October 1961, the dredging pond had reached a diameter estimated at more than 300 feet and had been dredged to a maximum depth of 38 feet. From the pond the sand and water are pumped at a rate of 1,200 gallons per minute at 15 percent solids to the classifying tower several hundred feet away. The oversize sand and gravel are scalped, screened to plus ½-inch, and ½-inch x 6-mesh sizes, and stored for possible future use. The underflow passes to a recently installed Dorr-Oliver "Jet Sizer," where the sand is classified hydraulically into 8 size ranges. By controlling the amount of water flowing into each of 8 sections of the Jet Sizer, hindered settling is effected and successively finer size ranges of sand can be obtained as desired. For example, in July 1960, the Jet Sizer was classifying mostly

12 and 16 mesh sand in the first section and 40 mesh in the seventh section, with intermediate sizes in sections 2 through 6. The eighth and last section classified minus 40 mesh sand and larger fragments of low density charcoal, punky shale, and trash, which are either wasted or sold as soil fill. Overflow from the classifier goes to the settling pond where fine sand and silt are wasted and water returned by percolation to the ground water system. The position of the settling pond between the ocean and the dredging pond probably helps to prevent the saline ocean water from contaminating the ground water. After classification, the various grades of sand are dewatered, either individually or in combinations, by two screw classifiers. Sandblasting sand, plaster sand, and other types of sand are stored in open-faced concrete bins to await shipment or further processing.

In late 1960, the company completed a new screening and drying facility adjacent to their classifying section. Here, the sand is dried in a gas-fired rotary drier and classified by 9 sets of Sweco vibrating screens. The classified sand is stored in separate bins which all feed to a blending belt located below, where the sand is blended to specifications. Capacity of the screening section is estimated to be 40 tons per hour. Blended sand is sold mainly for sandblasting, but some is used for filtration and other specialty uses. In October 1961, the dried sand sold for \$5.20–\$7.20 per ton for bulk and \$8.20-\$10.20 per ton sacked, the price variation depending on the amount ordered.

Production from the Lapis sand plant is shipped dry or wet, sacked or bulk, and by truck or rail. The company also operates another sand plant at Prattco siding near Seaside (see below).

Pacific Cement and Aggregates, Inc.—Prattco deposit. Location: N½ sec. 15 (proj.), T. 15 S., R. 1 E., M.D., west of State Hwy. 1 and about one mile north of Seaside. Ownership: Pacific Cement and Aggregates, Inc., 400 Alabama Street, San Francisco, leases from the State of California and from a private owner.

This deposit includes the beach and dune sands situated between Fort Ord and the Granite Construction Company sand deposit. The Prattco deposit acquired its name from Pratt Building Materials Company which operated a sand plant here beginning in May 1921 (Laizure, 1925, p. 55). In 1929, Pratt Building Materials Company merged with the present operator (then known as Pacific Coast Aggregates, Inc.) who has produced beach and dune sand for concrete, stucco, and sandblasting ever since.

When the operation was visited in July 1960, coarse sand was being dredged from the surf zone by means of a dragline scraper and stored at a surge pile. The sand is reclaimed from the base of the surge pile and conveyed a short distance to cable-operated hopper cars which travel along elevated tracks to a point near the railroad siding where the sand is bottom-dumped at a stockpile. Medium-grained dune sand is also stockpiled nearby. By means of dragline scrapers, beach and dune sands from the stockpiles are moved separately or together to a common surge pile. From here the sand is conveyed to a screen, and then stored in a bunker for bulk shipment by truck or by rail. No washing is done and only trash and oversized sand and gravel are screened from the sand. The relative amounts of beach (coarse) and dune (medium) sand used depend on the products desired, but it is estimated that about twice as much beach sand as dune sand is used.

The main products include blended sand for concrete, plaster, and gunnite and straight run beach sand for sandblasting (No. 4 sand). Plant capacity is estimated to be about 50 tons per hour. Two or 3 employees operate the plant. The sand plant is operated throughout the year, although the dredging of beach sand is frequently interrupted during the summer or fall when the sand becomes too fine.

Seaside Sand and Gravel Company deposit. Location: NW¼ sec. 24 (proj.), T. 14 S., R. 1 E., M.D., one mile northwest of Marina and immediately north of Monterey Sand Company's Marina deposit. Ownership: Seaside Sand and Gravel Company, Inc.—Floyd Bradley, owner, P.O. Box 116, Novato.

Seaside Sand and Gravel Company began producing beach sand from their Marina deposit in 1957. The sand, which is coarse and well-sorted (California Division of Mines, 1958, pp. 10–11), is moved by dragline scraper from the breaker and tidal zones to a nearby surge pile above the beach. From here it is reclaimed and conveyed to a washing section where the sand is washed over a screen and plus ½-inch gravel and trash are wasted. Fresh water, slightly brackish due to salt water intrusion in 1961, is obtained from a shallow well nearby. Next, fine sand and silt are washed from the sand in a rake classifier and the sand is stored for further processing. Surplus sand is stockpiled during the winter and spring for later processing in the summer and early fall when reduced wave action (and hence, smaller sand sizes) forces the cessation of dredging.

Semi-processed sand from the stockpile is dried in a rotary drier and conveyed to the screening section where the sand is separated into 6 size-fractions on 6-, 8-, 12-, 16-, and 20-mesh screens. The plus 6-mesh material is stockpiled for sale as roofing granules and water-well packings. The other fractions are stored in steel bins for later blending as desired. Most of the sand is sold for sandblasting purposes, but a little is used in plaster and concrete. Sand is shipped in bags or bulk. The company employs about 4 men to operate the plant.

Monterey Peninsula Area

Nearly white sand dunes of Recent age veneer much of the western margin of the Monterey Peninsula from Point Pinos to Point Cypress (Figure 16).

The dunes are most extensive opposite beaches where sand was available for wind transport. Hence, the largest dunes accumulated opposite Moss Beach southwest of Pacific Grove and near Fan Shell Beach east of Point Cypress. Prior to mining, the dunes at Moss Beach extended almost one-half mile inland and had a maximum elevation of more than 150 feet. At Fan Shell Beach, the dune deposit extends more than one-half mile inland and rises to an elevation of 288 feet. The dune deposits north of Spanish Bay are too thin to be of commercial interest.

A large amount of sand has been removed from these dunes, beginning at least as early as 1903, when sand was shipped to San Francisco for glass manufacture. The deposits may have been used prior to that as the quality of the sand was recognized by Whitney in 1865 (p. 161–162). He considered the dunes of Monterey Peninsula to be practically inexhaustible, but today the Recent dune sand reserves are nearly depleted. In addition to being used for glass, the sand was and is used widely for many specialty and structural purposes. As far as is known, there are no substantial differences between the dune sands found near Fan Shell and Moss Beaches. In both areas, the sands are medium-grained, well-sorted, and subangular. They consist of nearly equal parts of clear quartz and cream to white feldspar, with minor amounts of biotite and other heavy minerals, trash, and occasional rock particles. The sand deposits are operated and processed by two companies—Del Monte Properties Company and Owens-Illinois (described below).

Coarse, modern beach sand, composed mainly of quartz, feldspar, and composite grains derived from porphyritic granodiorite, also has been utilized by Del Monte Properties Company, and possibly others. Present and future utilization of the modern beach sands are limited by the small size of the beach deposits and by residential and recreational development on Monterey Peninsula. The dune and beach sand resources of Monterey Peninsula are essentially nonrenewable, sand replenishment by wave and wind action being much less than the excavation rate.

An older sand deposit—the Sawmill Gulch deposit, about one mile south of the Del Monte Properties Company plant—of rather diverse origin is included

Photo 33. Pit face at Fan Shell Beach dune deposit of Del Monte Properties Co. Note cross-bedding in this medium-grained, well-sorted sand.

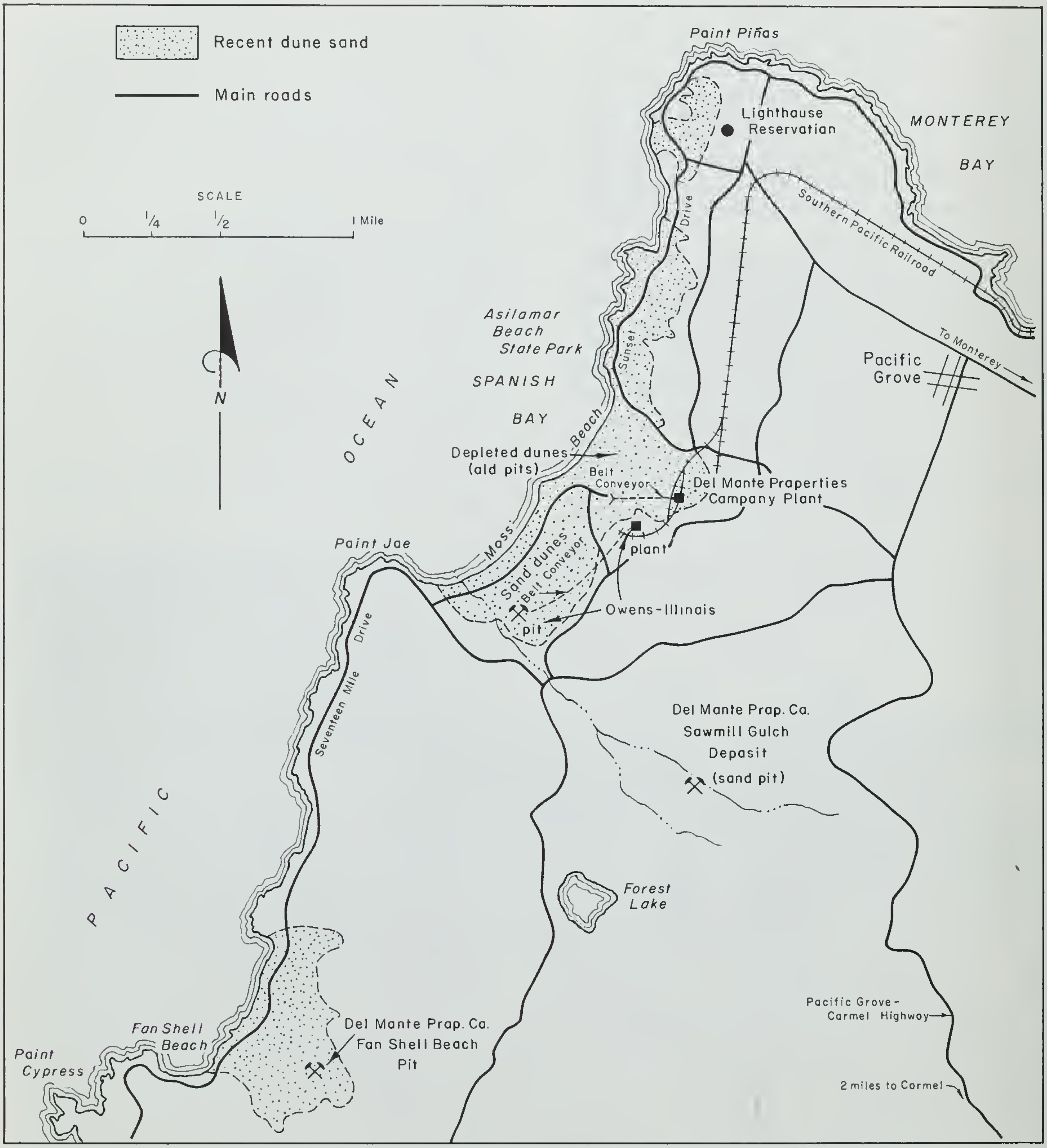

Figure 16. Sand plant and sand deposits near Pacific Grove, Monterey Peninsula.

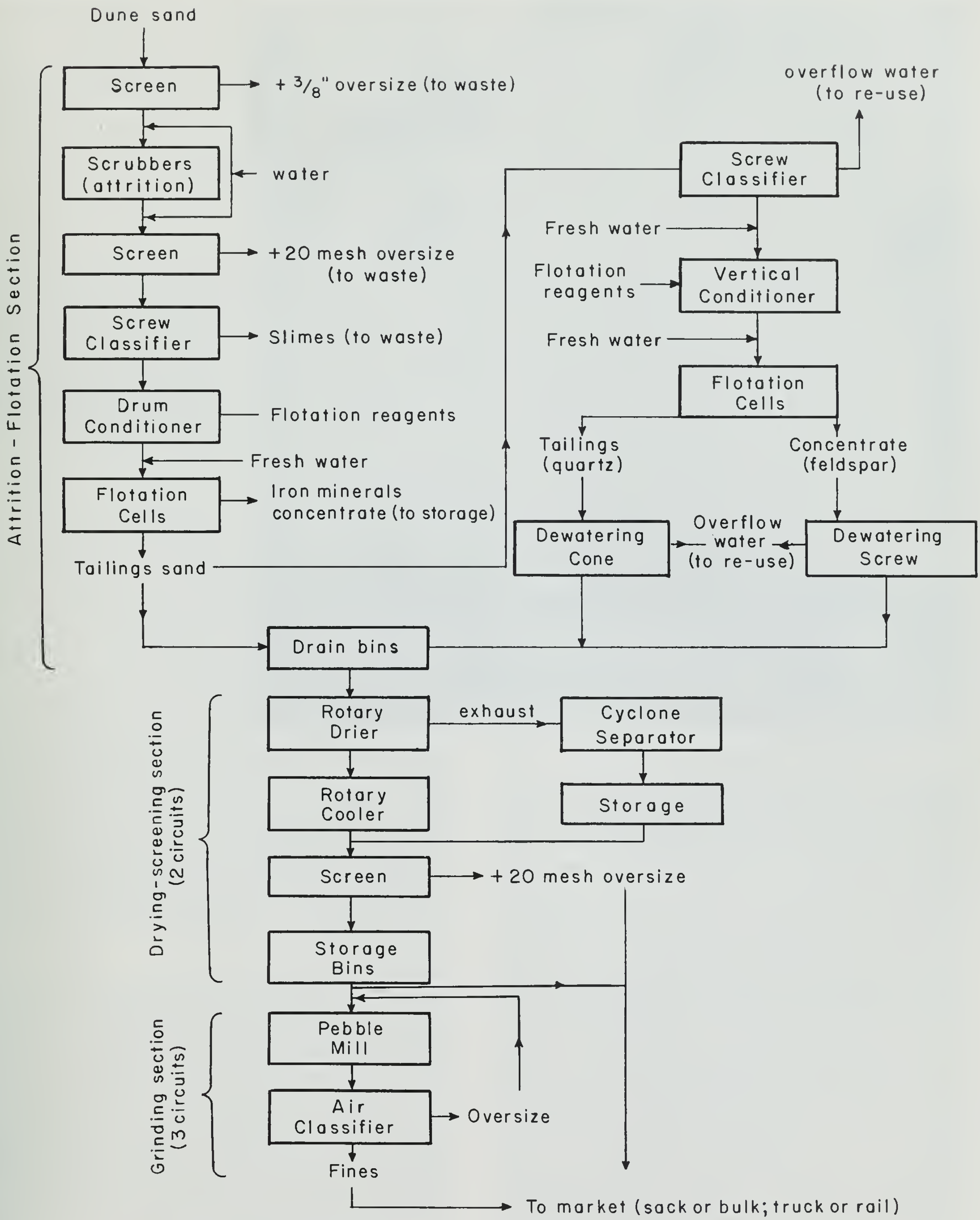

Figure 17. Generalized flow chart, Del Monte Properties Company sand processing plant.

Photo 34. Del Monte Properties Compony neor Pocific Grove. Dune sand from Fan Shell Beoch deposit is trucked to plont, where it is screened, scrubbed, ond beneficioted by flototion. Resultant quortz, feldspar, and quortz-feldspor products ore further prepored for market by grinding, clossifying, and blending.

in this subsection as it appears to be partly of dune derivation. The deposit contains dune-like sand interbedded and partly intermixed with granitic wash and clay, and apparently lies on a Pleistocene(?) wave-cut terrace. Exploratory drilling and excavation show the deposit to average about 30 feet thick and extend over at least 300 acres.

Del Monte Properties Company—Fan Shell Beach deposit. Location: SE¼ sec. 33 (proj.), T. 15 S., R. 1 W., M.D., 4 miles southwest of Pacific Grove near Fan Shell Beach. Ownership: Del Monte Properties Company, 620 Market Street, San Francisco.

Exactly when this deposit was first developed is unknown, although J. D. Whitney (1865, p. 161–162) recognized the dune sand as a potential source of glass sand at an early date. The Fan Shell Beach deposit has served Del Monte Properties Company as their principal source of specialty sand since 1955 and as a subsidiary source prior to that. Before 1955, Del Monte's main source of sand was the Moss Beach dune deposit (which see under Owens-Illinois—Moss Beach deposit), 2 miles to the northeast, where their processing plant is located (see Figure 16). They also obtained minor amounts of coarse beach sand from Fan Shell and Moss Beaches until the mid-1950's for aggregate and sandblasting purposes. Del Monte Properties Company and its predecessor prior to 1921—Pacific Improvement Company—have mined and processed sand on Monterey Peninsula since 1903. Descriptions of the companies' early activities are given by Aubury (1906, p. 278), Waring and Bradley (1919, p. 614), Boalich (1921, p. 157), Laizure (1925, p. 54–55), Sampson and Tucker (1931, p. 440) and Wright (1948, p. 44–45).

The Fan Shell Beach dune deposit covered at least one-quarter of a square mile originally, but in 1961 had been reduced to a single large dune, several hundred yards from the beach. The sand reserves of this dune are not accurately known because the dune lies on an irregular erosion surface. When visited in October 1961, the excavation pit had an advancing face 40 feet high and bottomed on weathered granodiorite. The deposit was being worked by a clamshell, which loaded directly into 8-cubic-yard dump trucks. The trucks hauled the sand 2 to 3 miles by road northeast to a grate-covered hopper located west of the plant. Sand from the hopper was conveyed 1,200 feet to a large, primary stockpile at the plant.

The processing plant, located near the north entrance to Pebble Beach, was revised section by section in 1952 and 1953 to replace the concentrating tables and magnetic separation units and to augment the grinding facilities. The plant has been described in detail by Messner (1954, pp. 5–8), Lenhart (1952, pp. 100–103), and Utley (1953, pp. 90–92).

The plant in 1961 consisted of 3 basic processing sections — attrition-flotation, drying-screening, and grinding. Sand from the primary stockpile is screened to remove gravel and trash and then fed with water (70 percent solids) to a battery of attrition machines where iron oxide and other undesirable coatings are removed from the grains. Next the sand is passed through a 20-mesh screen where oversize material is wasted. Slime and fines are then removed by a screw classifier. Sand and flotation reagents are intimately mixed in a drum conditioner prior to flotation. Conditioned pulp is reduced to 25 percent solids with fresh water and pumped to the iron flotation circuit where iron-bearing minerals are concentrated at the surface and removed. The concentrate consists of biotite with small amounts of heavy minerals plus considerable admixture of quartz-feldspar sand. This concentrate is stored, but is not generally salable. Part of the sand tailings is sent to the drying-screening section and part to the quartz-feldspar flotation circuit for further segregation. At this point, the quartz-feldspar sand (tailings) contains about .075 percent Fe_2O_3.

The sand to be further segregated by flotation is dewatered by a screw classifier to 80 percent solids and discharged into vertical conditioners, where it is diluted with fresh water to 60 percent solids and the necessary flotation reagents added. After conditioning, the pulp is diluted with fresh water to 25 percent solids and sent to 4 flotation cells where the feldspar is floated off as a concentrate. The feldspar is dewatered by a 24-inch screw and sent to a drain bin. Quartz tailings are dewatered in a 6-foot cone and sent to a separate drain bin. When the quartz and feldspar fractions have drained to approximately 5 percent water, these products are ready for drying and screening.

Three basic sand products—quartz-feldspar sand from the iron flotation circuit and quartz and feldspar sand fractions from the quartz-feldspar flotation circuit—are processed in the drying-screening section. The quartz-feldspar sand is dried in a gas-fired, 5 by 16-foot rotary drier at a rate of 25 tons per hour. Fines from the drier are collected in an 8-foot cyclone and returned to the sand after the latter is cooled in a rotary cooler. The sand is passed through a 20-mesh screen, where a minor amount of slightly oversize sand is removed for storage and sale. The rest of the sand is stored in a large bin for marketing or sent to another section for grinding. Quartz and feldspar are dried and screened through a different circuit, and stored in bins for marketing or later grinding.

In 1953, the capacity of the grinding section was doubled by the addition of a third pebble mill and air classifier circuit. Any of the basic products can be ground in the new 10-foot by 96-inch Hardinge mill, which utilizes 1½-inch Coors high-alumina pebbles of 9 hardness. However, the other mills utilize flint pebbles from Minnesota or Europe and generally process the quartz and feldspar fractions. After air classification, the fines are stored for shipment and the oversize recycled through the mill, with the exception that oversize passing a 48-mesh screen is sometimes marketed.

Basically, 12 unblended, dried products can be produced at the Del Monte Properties Company sand plant. In addition, numerous blended products are available for marketing. These products are shipped by truck or rail in sacks or bulk. According to H. Benech, Plant Metallurgist-Chemist (1959, personal communication), the quartz product normally contains 98–99 percent SiO_2, 1 percent Al_2O_3 and .025 percent Fe_2O_3, and the feldspar product about 17 percent Al_2O_3 and .10–.15 percent Fe_2O_3. The company furnished a chemical analysis of ground quartz-feldspar produced about April 1959, as follows:

Oxide	*Percent*
SiO_2	80.68
Fe_2O_3	0.075
Al_2O_3	11.35
TiO_2	0.016
CaO	1.15
MgO	0.28
Na_2O	3.10
K_2O	2.69
Ignition loss	0.25
Total	99.591

Except for a few percent oversize, undersize, and heavy mineral fractions removed from the sand, the above analysis is probably fairly representative of the raw sand. Calculations based on this analysis and other unpublished analyses indicate that slightly over half of the sand is feldspar and a little less than half is quartz. In addition, sodic feldspar (probably oligoclase-andesine) is about twice as abundant as the potash feldspar.

About 30 percent of the sand processed at the Pacific Grove plant of Del Monte Properties Company is ground and used for porcelain, plumbing fixtures, ceramics, chemically resistant pipe, basic refractory manufacture, fiberglass, filler, abrasives, and fines in high specification concrete aggregate. The rest of the sand, plus a small amount of coarse sand from Monterey Bay, is sold unground and is used for stucco, plaster and mortar sands; brass, iron and foundry sands; filtration; glass; fiberglass; and sandblasting sand. Most of the products are sold in California, although some are exported to Oregon, Washington, Hawaii and elsewhere. Some of the Company's Pacific Northwest market is now supplied by their silica-feldspar sand operation at Emmett, Idaho, which was

purchased from the Gem Silica Company in 1956. A silica sand plant near Spokane, Washington, is expected to further supplant the Company's Northwest market.

Additional chemical, processing and market data are given for the feldspar concentrate in the section on Feldspar.

Del Monte Properties Company—Sawmill Gulch deposit. Location: Near center sec. 26, T. 15 S., R. 1 W., M.D. (proj.), 2 miles south of Pacific Grove. Ownership: Del Monte Properties Company, 620 Market Street, San Francisco.

The Sawmill Gulch deposit is a clayey, gravelly, sand unit that was formed under diverse, coastal conditions during the Quaternary(?) Period. The deposit is believed to have been first operated in 1947 when Fletcher Olmstead experimented unsuccessfully with sandy clay from Sawmill Gulch as a source of adobe (See Tabulation under *Clay*—Sawmill Gulch deposit). Later, about 1958–1959, the present owner drilled several holes and cut a trench just south of Sawmill Gulch to determine the economic potential of the sand. Continued development adjacent to the trench has resulted in a test pit that, in March 1963, measured an estimated 125 feet by 150 feet with an average depth of 10 feet. The excavated material had been extensively tested and the operator planned to develop the deposit as a source of specialty sand.*

As the Sawmill Gulch deposit is weakly consolidated and poorly exposed, its overall extent and composition cannot be determined by conventional surface mapping. Drill data shows the deposit to be as much as 45 feet thick and to extend over at least 300 acres between the north branch of Sawmill Gulch and Forest Lake. Topography (marine terraces) and shallow road cuts (exposing sandy soil) suggest that the deposit extends both north and south of the developed area. Data obtained from drilling indicates the deposit averages about 30 feet thick and rests on a gently-sloping, decomposed granodiorite surface that probably represents a former wave-cut terrace. A thin, poorly-developed soil overburden indicates the deposit to be relatively youthful in its formation. A lithologic description of the deposit is given in the following log, taken from a drill hole located 2,100 feet northeast of Forest Lake at an elevation of 250 feet:

Surface—1 ft.	Pale buff, unconsolidated sand.
1–13 ft.	Buff to yellow-brown, fine to coarse sand, weakly cemented with clay; contains scattered angular pebbles; sandy clay horizon at 8½ feet.
13–43 ft.	Buff to light gray, clayey sand; mostly medium-grained, well-sorted; contains brownish, pebbly sand (granite wash) near top, bottom and 31–35 feet.
43–45 ft.	Yellowish-brown sand and granite wash with sparse rounded pebbles to 2 inches.
45–65 ft.	Light gray, decomposed granodiorite.

Photo 36. Northeast face of test pit, Sawmill Gulch deposit. Here, crudely-bedded sand and fine gravel is overlain by 2 feet of dune(?) sand. Gravel and coarse sand are derived from nearby granodiorite.

Photo 35. Test pit in Sawmill Gulch sand deposit; developed by Del Monte Properties Company as a potential source of specialty sand. Deposit averages about 30 feet thick and probably is Quaternary in age.

* Del Monte Properties Company reported that the Sawmill Gulch sand deposit was being used as the company's sole source of sand in 1965, replacing the Fan Shell Beach dune sand deposit as their source of specialty sand.

Photo 37. Sand dunes near Moss Beach are utilized by Owens-Illinois for glass manufacture. Sand is bulldozed to stockpile, reclaimed, and conveyed 2,400 feet to processing plant. Area in foreground has been stripped of dunes which once were thought to be inexhaustible.

At the test pit, 300 yards northwest of the above hole, similar materials are exposed to a depth of 15 feet. Here the upper 2 to 8 feet consists of medium-grained sand (probably dune-derived) locally indurated with clay. Beneath is a crudely-bedded sequence of clayey sand interspersed with pebbly sand beds and sandy clay lenses. This sequence is at least 12 feet thick and dips about 4° NW. Based on mechanical analyses of one pit-run sample and 2 select samples collected by the author from the south side of the pit, the material exposed by excavation would appear to be composed of 75–80 percent sand, 5 percent gravel, and 15–20 percent silt and clay. The sand sampled has a grain size distribution similar to that of the medium-grained dune sands currently mined on Monterey Peninsula and probably is largely of wind-blown origin. However, the angular, coarse sand and fine gravel interbedded and otherwise intermixed with the medium-grained sand undoubtedly is granite wash that is locally derived. The presence of clay indicates ponding also played an important role in the original deposition. It is possible the deposit formed in a coastal lagoon which was filled by wind-blown sand from the shore and granitic wash from the land.

Mineralogically, the gravel and coarse sand consists of decomposed granodiorite fragments, quartz, and feldspars with minor amounts of siliceous shale and woody organic trash. In the predominant medium sand sizes, quartz and potash and soda feldspars constitute the bulk of the sand. Fine sand and silt are similar in composition to the medium sand, but show increasing amounts of biotite (to 5 or 10 percent) with decreasing size. In general, the following conditions prevail: 1) The clastic material is subangular to angular; 2) the quartz is mostly clear and bright; 3) decomposition of the feldspars is notable; 4) the quartz-feldspar ratio is about 3 :2; and 5) a small percentage of grains are stained with iron oxide.

Although the Sawmill Gulch deposit contains a relatively high percentage of waste, the owner indicates that a variety of suitable specialty sand products can be obtained by normal processing methods. Del Monte Properties Company planned to develop this as their principal sand source, the sand to be processed at their plant one mile north of the deposit. As of March 1963, the company was constructing a mill section to remove clay, storage tanks and other handling facilities, and a waste pipeline from the plant to the ocean.

Owens-Illinois—Moss Beach deposit. Location: SE¼ sec. 22 (proj.), T. 15 S., R. 1. W., M.D., 2 miles southwest of Pacific Grove just west of Seventeen Mile Drive. Ownership: Del Monte Properties Company, 620 Market Street, San Francisco; the southern part of the deposit is leased by Owens-Illinois, 350 Sansome Street, San Francisco.

The Moss Beach dune sand deposit lies opposite Moss Beach, extending approximately from Sawmill Gulch on the south to Sunset Drive on the north (Figure 16). It includes what was formerly known as the Lake Majella deposit. The first definite record of production was in 1903 when Pacific Improvement Company shipped sand to San Francisco for glass manufacture (Aubury, 1906, p. 278). Pacific Improvement Company and its successor, Del Monte Properties Company, worked the deposit continuously until 1955 when the northern portion of the deposit became more or less depleted. The sand was used in glass and ceramic manufacturing, as building, molding, foundry, sandblasting and filter sands and for other specialty purposes. Since 1955 Del Monte has obtained sand largely at the Fan Shell Beach dunes 2 miles to the

south (for descriptions of that deposit and recent plant operations see *Del Monte Properties Company—Fan Shell Beach deposit*).

The southern part of the Moss Beach deposit was leased to Owens-Illinois, who has produced large amounts of glass sand from the deposit continuously since 1943. This sand has been used to supply the feldspathic raw material necessary in the company's production of flint and colored glass, with the exception that a minor amount of biotite-rich heavy minerals has been sold for roofing and other purposes. The sand produced by Owens-Illinois is similar to other dune sand of the north Moss Beach and Fan Shell Beach deposits, being nearly white, medium grained, and well sorted. It is composed mainly of quartz and feldspar in subequal parts, with a small amount of biotite and other heavy minerals. The raw sand contains 0.12-0.15 percent iron oxide, about half of which is stains on the quartz and feldspar.

The sand is obtained from dunes covering an area some tens of acres in size and rising as high as 40 feet above the weathered granitic rock of a wave-cut terrace. Dune sand is bulldozed a maximum of 100 yards to a conical surge pile, at the base of which is a reclaiming tunnel. A vibrating hopper feeds the sand to a 24-inch conveyor belt which moves the material 2,400 feet northeast to a storage pile at the processing plant. Every 2 or 3 years, when the sand deposit is locally depleted, the reclaiming tunnel, hopper, and part of the conveyor system are removed to another part of the sand deposit. When visited in July 1959, the bulldozer operator was able to supply the plant with sufficient sand by working half a day for 5 days a week.

At the processing plant, raw sand from the storage pile is passed through a 1¼-inch mesh screen to remove occasional rocks and trash, and is stored at a surge pile. At a drawpoint, sand is reclaimed from the base of the surge pile as needed for processing in the enclosed washing section. The present washing section was installed in 1952 to replace an earlier installation. The sand first is washed in a trommel with a 12-mesh screen where water is added, and oversize (mostly pine needles) is removed. Next, the sand goes to a rake classifier where organic material and silt are removed, the water and fines flowing to a thickener nearby. A horizontal vacuum filter then dewaters the sand to 5½ percent water at a capacity of about 50 tons per hour and the sand is stored for subsequent drying. Some of the water used in this section is obtained from the municipal water system, but much of the water is reclaimed from the thickener. Sludge from the thickener is wasted.

After washing and classification, the sand is conveyed to the drying section where it passes through a rotary drier and rotary cooler. Fine sand from the drier exhaust is collected in a cyclone separator and recombined with the dried sand, which is elevated to a storage silo in the magnetic cleaning section of the plant.

Most of the sand stored in the magnetic cleaning section is processed by a battery of 14 Dings induced-roll, magnetic separators which remove the iron-bearing minerals from the sand. The magnetic fraction, which consists mainly of biotite with small amounts of ilmenite, garnet, monazite and other heavy minerals, is stored for possible future sale. Small tonnages of this material have been sold to manufacturers of roofing paper in the past. All of the magnetically cleaned sand and the sand not processed by magnetic separation are shipped by rail to the Oakland, Portland, and Tracy glass container plants of Owens-Illinois. Both products are used for their aluminous content (feldspars) and are admixed with silica sand from the company's Ione, California, plant. The company refers to the magnetically-cleaned sand as "flint" sand, which has an average iron oxide content of about 0.07 percent. The flint sand is used in the manufacture of clear glass. Sand not processed by magnetic separation contains 0.11-0.12 percent iron oxide and is used to make colored glass. Chemical and screen analyses of "flint" sand sampled April 1959 are given in Table 6. The processing plant operates 5 days a week and 8 hours per day, except for the magnetic cleaning section which is operated two shifts a day. Seven men were employed in July 1959.

Quaternary Stream Deposits

Reported production of sand and gravel from stream deposits has averaged nearly 500,000 short tons per year from 1959 to 1964. This is about twice the aver-

Photo 38. Owens-Illinois sand plant. Moss Beach dune sand, after screening and washing, is dried (right) and magnetically cleaned (background tower). Thickener tank (left) enables operator to reclaim water.

*Table 6. Chemical and screen analysis of Moss Beach "flint" sand produced by Owens-Illinois.**

Chemical analysis		Screen analysis	
Oxide	Percentage	U.S. sieve size	Percent retained on
SiO_2	80.44	20	0.0
Al_2O_3	11.68	30	0.6
Fe_2O_3	0.069	40	7.7
TiO_2	0.011	50	40.2
Na_2O	3.11	60	28.4
K_2O	2.79	70	16.4
CaO	1.66	80	5.9
Ignition loss	0.24	100	0.7
		140	Tr
Total	100.00%	−140	Tr
		Percent heavy minerals	0.013

* Sample collected by Owens-Illinois April 1959 and analyzed by S. F. Taylor, Chemist.

age production for the preceding 6 years and was due largely to increased highway construction.

Except for a few more or less continuous operations located near population centers in Monterey County, most of the sand and gravel is produced with portable equipment at pits located close to large construction projects. Upon completion of these projects, pit operations generally cease and the equipment is moved to another project. By far the largest use of stream sand and gravel is for crusher run base, concrete treated base, plant mix surfacing (i.e., asphalt concrete), and imported borrow in road construction. Only a few of the developed deposits provide materials of high enough quality for use in concrete. Other uses of sand and gravel include backfill, drain rock, filtration gravel, and roofing, landscaping and driveway gravel.

Stream deposits generally can be classified according to how they are formed and their present position within a given stream drainage. The following nomenclature is used for deposits described herein:

Stream channel—the present bed where a natural stream of water runs. The dry bed of an intermittent stream is called a *dry wash*.

Flood plain—that portion of a stream valley which is built of sediments as a result of periodic overflow of the present stream channel. The flood plain sediments are usually fine grained, but they may include coarser material of former stream channels.

Terrace or alluvial terrace—erosion remnants of an older flood plain which lie above the present flood plain.

Alluvial fan—a low fan-shaped feature formed by the deposition of sediments at the mouth of a stream valley where the stream leaves the mountains and enters an adjacent valley or plain.

Because the various deposits within a given stream valley are composed of similar rock material, the best quality and most easily developed deposits are usually developed first. In a great majority of cases, the shallow stream channel (or dry wash) deposits are less weathered and more accessible than the older and often thicker flood plain, terrace and alluvial fan deposits. They also require less beneficiation and are nearer to water supplies. Another advantage of channel deposits is that the aggregate resource is at least partly renewable as a result of periodic flooding. Monterey County is no exception to these generalities, and virtually all of the better quality material (i.e. other than that used for fill or imported borrow) has come from present stream channels or the younger portions of flood plains and alluvial fans adjacent to the present stream channels.

In addition to the variations existing between the different types of deposits of a given stream valley, there are very important variations that exist among the different drainages of the county. Variations in the composition of sand and gravel directly affects the physical and chemical quality of the aggregate. As can be seen on the Geologic Map (Plate I), a wide variety of formations supply the numerous stream drainages with many different kinds of rocks. The effects of weathering, stream transportation, and other factors further modify the composition, shape and size-distribution of the rock debris so that the final stream deposit is unlike any other deposit, either in the same stream valley or in other drainages.

The most important stream deposits in the county are tabulated in Table 7, where the type, description, and past development of the deposits are summarized according to stream drainages. An effort is also made to assess the potential value of the deposits and drainages with regard to possible future sources of aggregate material. The tabulation is necessarily arbitrary and incomplete. Much of the basic data used to draw conclusions were made available by the California Division of Highways (San Luis Obispo District, Materials Testing Section) in late 1959.

To 1962 the most important sources of stream sand and gravel have been the lower Carmel River and dry wash part of the Arroyo Seco. Although neither source contains material of outstanding quality, they are the best sources of structurally sound gravel in the northern and central parts of the county. The Salinas River deposits (channel, floodplain and terraces) are by far the largest in the county, but with few possible exceptions the coarse aggregate is considered unsuitable for use in portland cement and asphalt concretes and other structural uses where high quality is desired. Some of the terraces (Qt) shown on the geologic map (Plate I) are actually alluvial fans, in part, and are composed almost solely of material derived from adjacent tributary streams. As such, some of these fans, particularly along the front of the Gabilan Range, may contain material of good struc-

tural quality. Probably the best quality aggregate occurring in substantially large deposits are found in the lower course of the Sur River and in the middle and upper portions of the Nacimiento River. Unfortunately, these little-used sources are difficult to develop because of their relatively remote locations and because of recreational or military restrictions.

During 1960, at least 6 pits were active in Monterey County. Two of the operations (Valley Rock and Adobe Co. and South Counties Sand and Gravel Co.) were small and designed to meet a variety of local commercial needs. A third pit (Odello) supplied only minor amounts of filtration gravel on an intermittent basis. Two pits, (Haber and Wolter) provided road material under both private and public contracts. A sixth operation (Zabala deposit) was completing a large state contract for road construction materials. The deposits operated in 1960 are described below. With one major exception, the sand and gravel needs of the county are supplied by local deposits: coarse aggregate for portland cement concrete in roads and large structures is generally imported from Hollister (San Benito River gravel) and Logan Siding (crushed hornblende diorite) both in San Benito County. Other imported sand and gravel products also are used in marginal areas of the county as a matter of economics.

Haber deposit. Location: SW¼ sec. 16, T. 16 S., R. 1 E., M.D., on Carmel River east of bridge access to San Carlos Ranch. Ownership: E. H. Haber, leased to Granite Construction Company, Watsonville, in 1960.

The Haber deposit consists of Recent sand and gravel of the Carmel River channel which at this point is about 100 feet wide. The material is mainly of granitic derivation, but siliceous Monterey shale and metamorphic rock debris are present in small amounts. The early development history of this deposit is not known. Immediately prior to October 1959, the deposit was operated by Fisher and Stokes, Contractors. After that, Granite Construction Company worked the deposit as a source of road construction material for the nearby Carmel Hill housing subdivision. It is reported that the California Division of Highways used this same material for crusher run base, subbase and concrete-treated base in constructing State Highway 1 near Carmel Hill.

When visited in July 1960, the present operator was dismantling a 1,200-ton per day capacity portable plant. Sufficient crushed gravel (about minus one inch) was stockpiled to complete the company's contract. It is reported that the sand and gravel was crushed, screened to two size fractions and recombined according to specifications. The material was not washed. By October 1961, a small stockpile of processed material remained on the south bank of the river and this was drawn from only intermittently. The sand and gravel was obtained from the present stream channel north of the plant site. No pit was observed in the area and it is probable that the company stripped the stream gravels to a maximum depth of 5–10 feet for some distance along the stream course.

Odello deposit. Location: SE¼ sec. 13 (proj.), T. 16 S., R. 1 W., M.D., on south levee of Carmel River just east of State Highway 1. Ownership: Bruno Odello, Carmel, leased to Monterey Sand Company, Box 928, Monterey, 1959.

This deposit was worked about 1927–1933 by a man named Machado, who obtained sand and gravel from the river channel. The present operation was initiated in 1950 when Monterey Sand Company constructed a washing-screening tower on the south levee (Bruno Odello, personal communication, 1959).

Sand and gravel are obtained from a relatively narrow stream channel (less than 100 feet wide) confined between two levees and flanked by extensive flood plains. The gravel is mostly well rounded and of granitic origin, but metamorphic rocks and siliceous and diatomaceous shale are present. Mechanical analyses are not available, but the sand appears to comprise well over 50 percent of the deposit. Water is obtained from a shallow well near the plant.

As far as is known, the present operation has been small and intermittent and in recent years the plant has been operated only infrequently. When the plant is operating, material is dredged by dragline scraper from a 6-foot-deep pond in the stream channel and stored at a surge pile adjacent to the washing-screening tower. The sand and gravel are washed and screened to 6 size-fractions ranging from coarse sand to 2-inch gravel. Undersize sand and silt are returned to the river and the oversize cobbles are discarded at a nearby waste pile. The sand and gravel products are stored in drain bins for subsequent loading and trucking to Monterey Sand Company's Sand City sand plant (described under Quaternary Beach and Dune Deposits sub-section). The material is reportedly used mainly for filtration purposes. When visited in October 1961, the dredging equipment was inoperative and vegetation was growing in the bottom of the dry stream bed.

South Counties Sand and Gravel Co. (Cazin) deposit. Location: NE¼ sec. 21, T. 18 S., R. 7 E., M.D., ½ mile south of Metz. Ownership: South Counties Sand and Gravel Co. (A. B. Woodward, owner), Metz Road, King City, owns 67 acres.

The deposit, located at the mouth of Chalone Creek just west of the Metz Road, was operated at least as early as 1949 or 1950 by Max Cazin and since 1958 by the present operator. Production has been continuous, but small, since 1950.

This dry channel deposit is several hundred feet wide, and about 15 feet deep. It consists of about 80 percent sand and 20 percent gravel, almost all of the latter being of minus 2-inch size. (The following data, although based primarily on sand and gravel just east of the Metz Road, are believed to be as applicable to the South Counties deposit as it is to the Metz Aggre-

Table 7. Summary of geology and development of important Quaternary stream deposits, Monterey County

Deposits (Stream drainages)	Geology of deposits: Type and extent	Geology of deposits: Description of materials present[1]	Development of deposits: Utilization	Development of deposits: Name and location of pits (see text or tabulation at end of report for details)	Remarks (Potential use, restrictions, etc.)
Arroyo Seco	Stream channel (dry wash) deposit; extends from confluence with Salinas Riv. upstream 20 miles; lower 10 miles of braided channels average ½ mile wide and over 15′ deep; upper course averages about 100′ wide. Little or no overburden; replenished during infrequent floods. Additional deposits may occur in the flood plain and alluvial fan in the lower course of the Arroyo Seco.	Mainly granitic with lesser Monterey shale, Sur Series rocks, and Tertiary sandstone; at Zabala pit 30–50% is sand and 10–12% is +3″; one mile from confluence with Salinas River size and percentage of gravel diminishes and percentage of shale increases; upper course of deposit has abundance of cobbles and boulders. Material is marginal quality for portland cement concrete; shale more common in gravel sizes than in sand.	Important source of asphalt concrete aggregate and base materials in road construction in recent years. No commercial development.	Zabala (W½ 35-18S-6E) Clark (SE¼ 23-18S-6E)	Large reserves make this important source of structural aggregate for Salinas Valley area. Strong afternoon wind causes dust and is major drawback to commercial development.
Carmel River (lower)	Stream channel deposit; extends 15 miles from mouth to junction Tularcitos Cr.; channel relatively narrow, averaging 100′ wide and over 15′ deep; little or no overburden. Partial replenishment during floods. Extensive flood plain on lower reaches may also contain gravel deposits under silty veneer.	Mainly granitic with some Sur Series and Monterey shale type rocks; maximum gravel size about 8″ at head of valley; diminishes to 4″ maximum near State Highway 1 where it is excessively sandy. Some unsound and potentially reactive gravel makes deposit marginal for portland cement concrete.	Constant exploitation since 1920. Commercial production small—used for portland cement concrete, roofing gravel, drain rock. Non-commercial production large, intermittent—used for asphalt concrete and base materials in road construction.	Valley Rock & Adobe Co. (SE¼ 24-16S-1E) Haber (SW¼ 16-16S-1E) Wolter (NE¼ 21-16S-1E) Morse (SE¼ 29-16S-2E) Odello (SE¼ 13-16S-1W) Otey (W½ 13-16S-1W)	Channel deposit reserves probably moderate; rate of replenishment during flood is small compared to mining. Flood plain deposits may be large but not developed.
Carmel River (upper) and tributaries (includes Chupines, Tularcitos, San Clemente, and Cachagua Creeks)	Stream channel deposits locally developed, but generally narrow and shallow. Also, locally extensive flood plains and terraces.	Probably mainly granitic with Sur Series and minor Tertiary sedimentary types. Considerable variations expected among the different deposits (i.e. lithology, size-distribution, soundness, etc.).	Stream channel deposits supplied concrete aggregate to construct dams and spillway; also probably used for road construction.	California Water & Telephone Co. (NE¼ 8-18S-3E) and (SW¼ 24-17S-2E)	Deposits of limited accessibility, but potential source of road and dam construction materials for local projects.
Chalone Creek	Stream channel (dry wash) deposit; extends 3 miles upstream from confluence Salinas River; averages 150′ wide, widening near mouth where it is at least 15′ deep. Partial replenishment is effected during occasional floods.	Gravel consists mainly of acid volcanic rock (85%) with some granitic rocks and minor amounts of metamorphic rocks, serpentine, sandstone and shale; sand is mainly granitic with some volcanic fragments; at South Counties' pit, sand is 80% of deposit. Small percentage of plus 1½″ at confluence increase to about 10% plus 2″ 2–3 miles upstream.	Modest past production. Material used since 1910–1920 for portland cement concrete, bituminous aggregate, drain rock. Sand used with imported gravel for state projects.	South Counties (NE¼ 21-18S-7E) Metz (NE¼ 21-18S-7E)	Tests made by California Div. of Highways indicate gravel is sound and durable, but possibly reactive with high alkali cement.
Nacimiento River	Stream channel and flood plain deposits; extends from south county boundary upstream 20 miles; lower 11 miles as much as 1,000′ wide; upper reaches average 50–100′ wide. Additional deposits extend from Nacimiento Dam in San Luis Obispo Co. to confluence Salinas River in Monterey Co.	Mainly granitic and Sur Series rocks with less Franciscan type rocks and younger sandstone; gravel is coarse with abundant 3–6″ gravel near San Miguel Creek and abundant 3–4″ 7 miles downstream near U.S. Army pit.	Deposits utilized by Hunter-Liggett Military Reservation, but uses unknown. Deposits downstream from Nacimiento Dam (San Luis Obispo Co.) used to construct earthfill dam and concrete spillway.	U.S. Army (E½ 32-23S-7E)	Probably one of best quality deposits in county, but remoteness and military control prevents commercial development.
Northern Gabilan Range (includes Gabilan, Alisal, Quail and Natividad Creeks, and Chualar, Johnson and Henry Sands Canyons)	Stream channels (dry washes) and alluvial fans; channel deposits are mostly small; fans at stream mouths more extensive and locally lie on or interfinger with Salinas River alluvium.	Mainly derived from granitic rock and some Sur Series rock types; physical properties variable; fans probably are predominantly sandy.	Production entirely non-commercial; use mainly for road construction as plant mix surfacing, imported base, concrete treated base. Sand at Bardin Estate deposit possibly used for portland cement concrete.	Bardin Estate (S½ 2-15S-3E) Bardin Ranch (20-14S-4E) Hurt Ranch (SE¼ 12-15S-4E) La Macchia (NW¼ 29-16S-6E)	Channel deposits may be useful locally, but are small; fans potentially useful for road construction; dry streams present water problem; but groundwater may be available at depth.
Northern Sierra de Salinas (includes Toro Creek, San Benancio Gulch, Watson Creek and Calera Canyon)	Stream channels; mostly narrow and shallow.	Mainly granitic debris in sand and fine gravel sizes.	Used by county and state for base materials and plant mix aggregate in road construction.	Ferrini (NW¼ 17-16S-3E)	Probably limited to use as local source of road construction material.
Pancho Rico Creek	Stream channel (dry wash) deposits; extends several miles upstream from Salinas River; maximum width 100′; probably shallow.	In NE¼ 16-22S-10E gravel composed of sandstone, acid volcanic, granitic, Sur Series, Franciscan rocks, and siliceous and clay shales; sand mainly quartz and feldspar with rock fragments and mica; maximum gravel size 3″ or 4″; gravel comprised about 50% of sample examined.	Used by state for borrow and possibly base materials in highway construction.	Brennan (NW¼ 15-22S-10E)	Gravel contains soft or flat fragments of sandstone and shale; siliceous shale and some volcanics possibly reactive with high alkali cement.
Salinas River	Stream channel, flood plain, and terrace deposits; extends entire length of county; valley many miles wide, and channel locally one mile wide.	Mainly granitic and Tertiary sedimentary rocks including significant amount of clay shale and opaline shale; sand predominates over gravel except for local gravel lenses.	Some intermittent past production of stream bars and terrace gravels for road construction. No recent production except possibly for borrow. When used as portland cement aggregate in road, pavement deteriorated due to alkali reaction with siliceous shale.	Unnamed (SW¼ 24-20S-8E) State pits (near Bradley)	High proportion of unsound and reactive material restrict the use of this deposit mainly to imported subbase and borrow for roads.

Table 7. Summary of geology and development of important Quaternary stream deposits, Monterey County—Continued

Deposits (Stream drainages)	Geology of deposits		Development of deposits		Remarks (Potential use, restrictions, etc.)
	Type and extent	Description of materials present[1]	Utilization	Name and location of pits (see text or tabulation at end of report for details)	
San Antonio River	Stream channel deposit; extends about 40 miles upstream from confluence Salinas River; maximum width about 1,000′; upper 10–15 miles much narrower. Reserves in lower portion of river undoubtedly large.	Lower course of river is excessively sandy and gravel reported to be composed of abundant soft Tertiary sediments. However, U.S. Army pit 30 miles upstream from Salinas River consists of 50% gravel with abundant +1½″ sizes; gravel subrounded and mainly granitic and metamorphic with lesser amounts of sandstone and shale.	Local use at Hunter-Liggett Military Reservation.	U.S. Army (SW¼ 29-22S-7E)	Highest use of downstream portion of deposit probably restricted to imported subbase and fill. Better quality deposits occur in upper course of river and possibly in tributaries.
San Lorenzo Creek-Lewis Creek	Stream channel deposits; extends many miles upstream from confluence Salinas River; at Boyd pit deposit is 100-200′ wide and over 10′ thick; at Eade pit near confluence Lewis Creek deposit is about 100′ wide and probably shallow. Gravel deposits in flood plain and stream terraces may be extensive downstream (e.g. at Monterey County pit), but have thin soil overburden.	Near mouth at Boyd pit, gravel consists of Franciscan types with lesser granitic, Tertiary sedimentary and volcanic rocks and comprises about 20% of deposit. Upstream at Eade pit, gravels are 50% of deposit. Terrace deposit at Monterey County pit is over 50% gravel with abundant sizes to 4″; gravel has similar lithology to channel gravel but is more weathered.	Intermittent production of channel deposits for many years; main use is for bituminous aggregate and imported base materials for county and state roads; county pit in terrace deposit also supplied plant mix and crusher run base material.	Eade (N¼ 14-19S-9E) Boyd (4-20S-8E) Monterey County (?) (SE¼ 33-19S-8E)	
Sur River	Stream channel deposit; extends upstream 1 mile from ocean; maximum width about 500 feet and average about 200 feet; at least 10′ deep. No overburden; replenished in flood stages. Additional deposits may occur in adjacent flood plain.	Mainly granitic rocks with lesser Sur Series and Franciscan type rocks; gravel comprises over 50% of deposit one mile upstream where 10–20% is +3″ and boulders are common. Gravel is subrounded and appears to be sound and durable.	Used by State Div. of Highways for structural backfill and by U.S. Navy for housing development; commercial use spotty and small.	Molera Ranch (NW¼ 15-19S-1E)	Limited test data indicate material to be excellent for portland cement concrete and all road construction uses. Development possibly restricted by residents or county.

[1] *Sur Series* rocks consist of gneiss, schist, crystalline limestone, quartzite and contact metamorphic rocks; *Franciscan type* rocks—includes indurated sandstone, chert, greenstone, serpentine, and vein quartz mainly; *Monterey shale*—mainly opaline shale with some clay shale and diatomaceous rocks.

gate Co. deposit.) According to an unpublished report of the California Division of Highways by H. D. Woods (1952), a sample of gravel from Metz Aggregate Company's raw materials stockpile, located immediately upstream, consisted of 85 percent volcanic rocks (mainly rhyolitic) and small amounts of quartzite, limestone, sandstone, schist and siliceous shale. Sand from the same place was composed of 85.6 percent granitic particles, quartz and feldspar; 9.3 percent volcanics; 3.9 percent mica; 0.6 percent siliceous shale; and 0.6 percent miscellaneous (mostly heavy minerals). Because partly-glassy volcanic rock and siliceous shale are present, the aggregate of Chalone Creek is considered to be potentially reactive with the alkali in portland cement, and preliminary tests seemed to bear this out in part. However, the material has been used successfully in concrete structures dating back more than 40 years. In addition, Chalone Creek sand was used with imported crushed granitic rock to make concrete for the State Prison at Soledad and for pavements and culverts in highway construction. After one to three years of service, none of the structures showed deleterious effects, according to Woods. This is too short a period to be conclusive and, unless proved otherwise, Chalone Creek aggregate (especially the gravel) should be used with low-alkali cement in making concrete. According to the results of several tests made by the California Division of Highways, Chalone Creek material has met all state specifications (as of 1952) for the physical quality of concrete aggregate. The continued local use of the gravel for concrete would seem to indicate the material can be used satisfactorily for concrete purposes. In addition, sand produced by South Counties was acceptable by the State Division of Highways for use with imported aggregate in portland cement concrete pavement for construction of U. S. Highway 101 in 1960–61.

South Counties Sand and Gravel Company purchased the deposit west of Metz Road in 1958 from Max Cazin, who produced only unwashed material for local use. (For additional data on the deposit east of Metz Road, see Metz Aggregate Co. in Tabulation at end of report.) The present pit is worked with two front-end loaders and dump trucks. The raw material is processed at an adjacent plant where it is washed and screened to four size-fractions—plus 1½-inch oversize, 1½-inch x ⅜-inch, ⅜-inch x ⅛-inch and minus ⅛-inch sand. The sand is classified by a 12-foot long screw. Maximum capacity of the plant is 50 tons per hour. Groundwater, obtained from a 120-foot well is reported to be ample. Oversize gravel is sold for drain rock. Most of the rest of the products are used for various local purposes, including concrete. The owner operates 4 transit mix trucks to supply local concrete needs. When specifications require it, crushed hornblende diorite from the Granite Rock Company quarry at Logan Siding, San Benito County, or gravel from the San Benito River near Hollister are used as the coarse concrete aggregate.

Insufficient data are available to determine the reserves of the South Counties Sand and Gravel Co.

Photo 39. Nacimiento River channel and flood plain deposit in sec. 32-23S-7E. This deposit is 100 yards wide and 1 mile long and is composed of good quality aggregate. This and other deposits along the Nacimiento River are mostly undeveloped due to distance from market and current military ownership.

deposit, but the presence of fine sand at a depth of about 15 feet at one point indicates sand and gravel reserves to be rather small. However, additional reserves are exposed in the channel for a distance of 3 miles upstream. Some material may also be present in the floodplain near the mouth of the Creek. The resources are partly renewed during infrequent floods (last one, winter 1957–58).

Valley Rock and Adobe Co. (Murphy) deposit. Location: SE¼ sec. 24, T. 16 S., R. 1 E., M.D., on Carmel River immediately east of Farm Center. Ownership: Valley Rock and Adobe Company (John B. Simpson, owner), P.O. Box 64, Carmel Valley.

Sand and gravel are obtained commercially from the present stream channel of the Carmel River by the Valley Rock and Adobe Co. who purchased the property from M. J. Murphy in 1955. The former owner first obtained material from the Carmel River about 1920, and established the present plant in 1928. The plant has been operated continuously ever since then on a small scale. The small, permanent, crushing-screening plant is located adjacent to the main pit.

The gravel, most of which is smaller than 2 or 3 inches, appears to comprise about 30–40 percent of the excavated material. It consists mainly of granitic rock with some metamorphic rocks of the Sur Series and a small amount of siliceous shale of the Monterey Formation (the owner estimates 3 percent siliceous shale). The gravel is rounded to subrounded. The sand is derived mainly from granitic rock and is subangular.

Sand and gravel are obtained from the stream channel within one-quarter of a mile of the plant. The material is partly replenished during occasional flood stages of the river. However, additional sand and gravel have been obtained from other points in the river channel within a distance of one mile from the plant. The material is excavated by a bulldozer and a small-capacity front end loader. A dump truck is used to transport some of the material to the plant.

At the plant, the gravel is crushed to minus 1½ inches and part of this goes to a bunker without washing. This product is sold locally, mainly as concrete aggregate. The rest of the material is washed in a re-

Photo 40. South Counties Sand and Gravel Co. pit at the mouth of Cholame Creek. Although wide near the mouth, this dry wash deposit narrows to 150 feet wide less than 1 mile upstream. The deposit is excessively sandy at this location.

Photo 41. Volley Rock ond Adobe Compony's sand ond grovel pit. This Carmel River streom channel deposit is narrow, being confined by levees over a distance of 15 miles upstream from the mouth. The stream normolly flows most of the yeor, but ofter three successive "dry" winters the channel was completely dry in October 1961.

volving trommel and sized by screens having ¾-inch, ⅜-inch and 4-mesh openings, the separate fractions being stored in individual bunkers. Sand (minus 4-mesh) is sold mainly to nearby Valley Transit Mix Co. for use in ready mix concrete; pea gravel (⅜-inch x 4 mesh) is sold mostly as driveway and roofing gravel; ¾-inch x ⅜-inch gravel is sold for concrete and 1½-inch x ¾-inch material is used by the owner for drain rock in the construction of septic tanks. Capacity of the plant is reported to be 100 tons per day.

Wolter Deposit: Location: NE¼ sec. 21, T. 16 S., R. 1 E., M.D., on the north levee of Carmel River. Ownership: Luis F. Wolter, Carmel Valley, leased to Phil Calabrese (contractor), Sand City, 1961.

This portion of the Carmel River channel has been worked intermittently for 10 years by Monterey County as a source of road construction material. The sand and gravel appears similar in size-gradation and composition to other nearby channel deposits (see under Haber and Valley Rock and Adobe Co.), being mainly of granitic origin. The channel deposit is about 100 feet wide, but the depth is not known. This property was leased early in 1960 by Phil Calabrese, who installed a portable crushing-screening plant of substantial capacity.

When visited in July 1960, sand and gravel was bulldozed from a shallow pond in the river channel into a surge pile. From there the material was conveyed to the portable plant where it was crushed to minus 1½-inches. Part of this was stockpiled directly and part screened to plus ⅜-inch and minus ⅜-inch fractions. The material was not washed. Most of the output was used by the operator to construct streets at a nearby residential subdivision, but some was sold to Monterey County for road construction material. The plant had been removed when last visited in October 1961 and only a small stockpile of crushed material remained. At that time, the river was not flowing.

Zabala deposit: Location: W½ sec. 35, T. 18 S., R. 6 E., M.D., 2 miles west of Greenfield. Ownership: Walter Zabala, Greenfield, leased to Delphia-Early Co. operating under a contract with the California Division of Highways, 1960.

The Zabala deposit has not been investigated sufficiently to determine its exact nature, but brief obser-

Photo 42. Zobola sand ond grovel pit neor Greenfield wos used os an important source af bose materials and ospholt concrete aggregote in construction of U.S. Highwoy 101 in 1958–61. Pit is developed in Arroyo Seco dry wash. The deposit is one of the lorgest in Monterey County, hoving a length of 10 miles and overoge width of about ½ mile.

Phata 43. Titus sand and gravel pit in San Benancia Gulch. Old pit face shows typical badlands type erosion features developed in the Pasa Rables Formation. Here the formation is a fanglamerate(?) composed entirely af partly weathered granitic debris.

vation suggests that it is part of the extensive Arroyo Seco channel and dry wash deposit which comprises the most recent portion of an alluvial fan covering some 30 square miles.

The deposit is developed by a roughly circular pit which is about 150 yards in diameter and 10-15 feet deep. Exposed in the pit face are poorly-stratified interbeds of sand and gravel. The material is poorly sorted and consists of 50 to 70 percent gravel which has a maximum size of about 10 inches. About 10 percent of the material is larger than 3 inches. Granitic rock with lesser amounts of metamorphic rock and Monterey shale (siliceous and clay) comprise the gravel. Granitic fragments, quartz and feldspar make up the bulk of the sand.

When the plant and pit were visited in June 1960, Delphia-Early was excavating the sand and gravel with a 2½-cubic yard shovel. The material was loaded directly into 18-cubic yard scrapers for an 800-foot haul to the stockpile located near a large capacity crushing-screening plant. Plus 3-inch gravel was scalped over a grizzly, crushed and recombined with the rest of the sand and gravel. The combined material was next fractioned on a ¼-inch mesh screen. The plus ¼-inch fraction was crushed to minus ⅞-inch and further separated on a 4-mesh screen. The various fractions obtained were then recombined according to specifications and dried in a rotary kiln to less than 1% moisture content. The dried aggregate was mixed with asphalt in a continuous run plant, completing preparation of the plant mix aggregate. The output was then trucked to U.S. Highway 101 for use as asphalt concrete pavement.

In this operation, the aggregate was not washed, the only water consumed being used as a spray to collect dust. Water was obtained from a nearby 105-foot well where the water table reportedly fluctuated between depths of 35 and 65 feet from season to season.

Although only plant mix aggregate was produced in June 1960, crusher run base, concrete treated base, and subbase materials were produced in 1959 for highway construction near Greenfield and Soledad. This state contract was completed in November 1960. Further detail of the early operations is reported in Pacific Roadbuilder and Engineering Review (1959, pp. 15–16). When last visited in October 1961, the plant had not yet been dismantled, although there was no activity.

Older Formations

Poorly consolidated and unconsolidated sand and gravel from formations older than the Quaternary beach, dune, and stream deposits described above are relatively widespread in Monterey County. Some of the older sand and gravel deposits may become economic sources of construction and specialty materials in the future. Formations most worthy of consideration are the Paso Robles Formation of Plio-Pleistocene age, Santa Margarita Formation of late Miocene age, Mon-

terey Formation of Miocene age, Vaqueros-Temblor formation of Miocene age, and Aromas Red Sands of Pleistocene age.

Paso Robles Formation. This Plio-Pleistocene formation generally consists of crudely stratified gravel, sand, silt and clay sediments deposited by stream action as widespread fans and valley alluvium. In most cases it consists principally of soft or siliceous (opaline) rock debris derived from Tertiary sedimentary rocks and, as such, is useful almost solely as fill and possibly as subbase material in road construction. Locally, however, the Paso Robles Formation is derived mainly from Santa Lucia granitic and Sur Series metamorphic rocks and may be useful as base and concrete-treated base materials in road construction. Examples of this type of deposit are exposed extensively at the Titus pit in San Benancio Gulch and the Gould pit near the junction of Reliz Creek and Arroyo Seco (see Tabulation for description of pits).

The Titus pit in NE¼ sec. 2, T. 16 S., R. 2 E., appears to be developed in a fanglomerate composed of granitic debris very similar in properties to decomposed granite, except it contains a small percentage of cobbles and boulders of somewhat angular and less weathered granitic rock and has been used as a base material in road construction.

The Gould pit, SW¼ sec. 15, T. 19 S., R. 6 E., exposes interbeds of sand and gravel similar in composition to the present channel deposit of the Arroyo Seco and possibly is an old stream bed deposit. It has been used by the county for fill in road construction but could be used as a source for road base materials.

Santa Margarita Formation. Although it has never been developed commercially, white sand of the Santa Margarita Formation appears to approach, in many places, the physical and chemical properties of the Recent beach and dune sand deposits which currently are exploited for construction and specialty purposes. As the present sources become depleted, or are otherwise unable to meet the market demand, it may be possible to develop sandy portions of the Santa Margarita Formation. This upper Miocene formation is typified by white to light gray, fine to coarse, poorly consolidated sands composed dominantly of quartz and feldspar, often with notable amounts of granitic debris. The sandy beds are locally interbedded with conglomerate or shale, and in some areas become predominantly shaly. The sandy portion of the formation is well-developed in the Cholame Hills (Taliaferro, 1943, pp. 457, 459–460), Calera Canyon area, and Tularcios Creek area (Fiedler, 1944, pp. 227–228, map). Other localities where Santa Margarita sand may be significant are shown on the Geologic Map (Plate I) as "Mu". Many of these sand deposits have been examined and/or tested preliminarily by several specialty sand companies and glass manufacturers. One of the most detailed studies was completed as an unpublished report, entitled "Northern California sand deposits", by E. W. Galliher in 1932. Some of his data, especially screen analyses, concerning the Calera Canyon and Big Sandy Creek (Cholame Hills area) deposits were reproduced and summarized by Wright (1948, pp. 67, 72, Table 38). Additional information concerning Santa Margarita sand deposits is given below:

Calera Canyon area. This area includes the Calera Canyon deposit sampled and examined by Galliher, who estimated it to contain 4,500,000 cubic yards of white to gray, poorly consolidated, quartz-feldspar sand with some biotite. The sampled north end of this deposit, N½ sec. 15, T. 16 S., R. 2 E., is now under development for home construction, so economic development of the sand is unlikely. However, other sandy units of the Santa Margarita Formation, extending 3 or 4 miles to the east and southeast, may be worthy of investigation. Several small pits in sec. 15 testify to the past utilization (probably by local ranchers) of the sand.

Cholame Hills area. Possibly the largest and best deposits of Santa Margarita sand are exposed in the Cholame Hills in T. 22 S., R. 12 and 13 E., and T. 23 S., R. 12, 13, and 14 E. The most northerly of these deposits, the Big Sandy Creek deposit in SW¼ sec. 17, T. 22 S., R. 13 E., was sampled and described by Galliher as a quartz-feldspar sand containing a small percentage of serpentine and other rock particles in the coarse fraction. The sand, which is poorly-sorted and sporadically cemented with calcium carbonate, is exposed on both sides of Big Sandy Creek for a distance of 2 miles southward from the sample locality. About 1955, a major glass manufacturer sampled the same deposit and, after washing and scrubbing, determined it to contain 0.13 percent Fe_2O_3 and 10.23 percent Al_2O_3. A scrub loss of 34.4 percent suggests that, in addition to the presence of clay, a great deal of the contained feldspar is decomposed. After magnetic separation in the laboratory, the Fe_2O_3 content was reduced to 0.10 percent, which is still too high for flint glass manufacture. Similar sand in sec. 17 is reported to have been used by the local ranchers for concrete and other purposes. To the southwest, in sec. 36, T. 23 S., R. 12 E., a small hillside pit exposes white Santa Margarita sand. Additional sand is extensively exposed in the Cholame Hills west of Cholame Valley, especially in T. 23 S., R. 13 E. Here the sands vary from fine to coarse, and comprise massive beds which are locally interbedded with gravelly strata and constitute a section as much as 2000 feet thick. The larger outcrop areas of sand have been differentiated as a sandy member of the Santa Margarita Formation by Taliaferro (1943, p. 459–60, Fig. 189). With the depletion of better sand deposits, and improvements in beneficiation methods, it is believed that deposits, such as described above, will be of important economic consideration as sources of specialty and construction sand. However, much more field and laboratory study is necessary to determine the best deposits.

Aromas Red Sands. Another formation of potential economic consideration is the Aromas Red Sands of Pleistocene age. Typically, this unit consists of reddish-brown, torrentially- to massively-bedded, sand and gravelly sand, often cemented with clay or iron oxide. The sand is easily excavated and consequently has been used locally as fill and subbase material in road construction. However, it may be possible to obtain fine-grained aggregate by washing Aromas Red Sands quarried from selected localities, but no test data are available to shed light on this potential. The Aromas is widespread in the Monterey Bay region and is shown on Plate I as "Qc".

Monterey Formation (basal sands). A possible source of sand about which little is known is the basal sand member of the Monterey Formation. This member is widespread in the Monterey Bay-Carmel Valley area and locally may be more than 200 feet thick. At most of the exposures observed, it consists mainly of granitic debris and is poorly consolidated and buff-colored. One exposure examined near Huckleberry Hill along the Carmel-Pacific Grove Road, consists of poorly sorted, fine to coarse sand locally cemented with iron oxide. It did not appear to be of commercial quality at this location.

Vaqueros-Temblor (undivided) rocks. An additional source of potential value is the white sand of the Vaqueros-Temblor unit of Miocene age. This sand is moderately well sorted, being medium to medium-coarse in average grain size. Quartz and feldspar are generally the main constituents, but granitic and metamorphic rock fragments are sometimes common. A thick belt of this white sand is reported south of Carmel River in SE ¼ sec. 23, NE ¼ sec. 26 and W ½ sec. 25, T. 16 S., R. 1 E. (O. E. Bowen, personal communication, 1961). Other sand occurrences are reported in the Jamesburg 15′ quadrangle to the south (Fiedler, 1944, pp. 194–223, Pl. IX).

SILVER

Silver was one of the first metals sought in Monterey County, argentiferous galena being explored as early as 1800 (Duflot de Mofras, 1844; Trask, 1854, p. 55–56; Blake, 1858, p. 301; Bancroft, 1886, p. 144, 176). Despite the early exploration efforts, which are of considerable historic interest, there is no record of the commercial production of silver in association with galena. All of the silver known to have been produced in the county occurred as an alloy of native gold and was obtained as a byproduct of gold mining. The reader is referred to the section on Gold for additional information on silver. Total recorded silver production through 1964 amounted to 494 troy ounces.

Alisal silver prospects. Location: Not definitely determined, but possibly partly situated in W½ sec. 29, T. 14 S., R. 4 E., M.D. (projected). Ownership: Above specified property owned by D. F. Davies, 1029 Old Stage Road, Salinas.

Silver was first discovered on or near the Alisal Rancho by Ignacio Ortega in 1800 (Bancroft, 1886, p. 176). This apparently was the first of several silver prospects developed in the mountains east of Salinas during the nineteenth century. Because published descriptions of silver prospects are mostly vague, especially with respect to precise locations, much confusion has developed regarding the identification and location of the various prospects. Therefore, this writer has made no attempt to examine all of the known workings (at least 4 or 5 sets of workings are known to the local residents) and correlate them with the prospects described in the literature.

The earliest geologic description was given by J. B. Trask (1854, p. 18, 55–56), who described the Alisal silver occurrences as argentiferous galena "in small veins and disseminated" in limestone on the west flank of the Gabilan Range. At one locality—not specified, but presumably on or near the Alisal Rancho—the argentiferous galena was explored by a 55-foot shaft that was sunk in limestone and bottomed in granite. Trask observed a metallic, "decomposed vein" as much as 4 or 5 inches thick that could not be traced below the limestone into the granite. The locality also was prospected by an incomplete cross-cut adit "driven from the west side of the hill." W. P. Blake (1858, p. 295, 301, 303) described the silver localities in somewhat more detail (although he didn't visit the prospects), stating them to be situated "at the Alisal Rancho" about 25 miles from San Carlos Mission in the foothills on the east side of the Salinas Valley. He examined specimens from three veins which were described as 1) rusty-brown, having "the appearance of an argentiferous galena"; 2) compact quartz with traces of iron and copper sulfide and stained with copper carbonates; and 3) containing pyrite and a small amount of "metallic arsenic". The veins were reportedly worked—apparently without success—in 1831, 1852, and 1855. Later writers (Waring and Bradley, 1919, p. 615; Laizure, 1925, p. 56; Goodwin, 1957, p. 571) added little to the earlier references and it is probable that little work has been done since the 1850's.

One of the prospects referred to by Trask and Blake may be on the Davies property in W½ sec. 29, T. 14 S., R. 4 E. (projected) which is part of the original El Alisal (Bernal) grant. This prospect was examined by this writer in March 1966 after an initial lead and detailed descriptions were kindly provided by J. O. Sturgeon of San Luis Obispo (written communication, February 1966).

Workings on the Davies property consist of an adit about 150′ northeast of Old Stage Road and two adjacent shafts 200-300 feet farther northeast. The adit apparently was driven northeast, but the portal is now blocked by rubble and soil. A trench leading to the adit exposes secondary calcareous deposits (calcareous tufa?) banded parallel to the hill slope. Upslope, the shafts are 10-15 feet apart at ground level and separated

by a thin wall at depth. They were sunk in crystalline limestone along a fracture zone that has a predominant dip of 45° SW. The northwest shaft is 25 to 30 feet deep and inclined steeply, but irregularly, to the southeast; the other shaft is vertical, about 20 feet deep and 8 by 12 feet in cross section. No well defined vein was seen in either shaft but exposures are somewhat obscured by dirt and secondary calcite. However, some massive, hydrothermally derived rock made up of quartz, chalcedony, common opal and iron and manganese oxides is exposed on the northeast wall near the top of the inclined shaft. A few feet below that is an irregular zone of altered yellowish material composed of calcite, nontronite and some quartz with local concentrations of pale brown garnet. No metallic minerals were seen, but spot chemical tests show a trace of arsenic and no silver to be present.

Other old workings are reported within a few miles of the Davies property and some of these may be part of the Alisal or Ortega prospects or at least may have been developed during the same early period of silver and copper prospecting. However, none of these other prospects were examined by this writer and none are known to have been productive.

STONE

Stone is the sixth most valuable commodity in Monterey County, total production through 1964 being close to four million dollars. Of this total, crushed and broken stone accounts for an estimated 3½ million dollars and dimension stone $450,530. In 1964, crushed stone production (excluding industrial uses) amounted to about 124,000 tons, valued at $389,304. No dimension stone has been produced since 1961.

The most important types of rock produced as stone products, with respect to value, are crystalline limestone and dolomite for roofing and landscape granules, decomposed granite for road construction materials, and siliceous shale for dimension (architectural) stone. Other types of rock used in the past include granodiorite and sandstone as riprap; sandstone, granodiorite, and crystalline limestone as dimension stone and rubble; and siliceous shale and other common rocks used as fill and road base materials. In addition, crushed crystalline limestone and dolomite have been used as poultry grit, athletic field markings, white mineral fillers, etc. Table 8 lists geologic formations that have been used or are potentially useful as sources of stone products. Fill (imported borrow) is not indicated, as

Table 8. Geologic formations in Monterey County containing potentially useful sources of stone products

Geologic age	Map symbol	Formations	Location and distribution	Suitable rock types	Possible uses	Commercial development (see tabulated list at end of report for more complete list of producers)
Miocene	Mm	Monterey Formation	Widespread west of Salinas River from Monterey to south county boundary	Siliceous and diatomaceous shales	Dimension stone	Important production since 1920's from Carmel Valley (Carmel Stone quarry—Passadori; Santa Lucia quarries; etc.). Minor production near San Ardo (Harold Yost)
	Ml	Vaqueros and Temblor Formations	Common in Santa Lucia Range; more restricted northern Gabilan Range and east of San Andreas fault	Massive sandstone	Crushed and broken stone	None
	Mv	Pinnacles Formation and undifferentiated volcanic rocks	Northern Gabilan Range; Pinnacles area; Cholame Valley	Rhyolite, andesite and basalt flows and breccias	Crushed and broken stone	None
Oligocene	Φ	Pinecate Formation	Northern Gabilan Range	Massive sandstone	Crushed and broken stone	None
		"Church Creek beds" (upper portion)	Along Church Creek in Santa Lucia Range	Flaggy sandstone	Dimension stone	Possibly source of stone for Tassajara Hot Springs Hotel
Eocene	E	The Rocks Sandstone and Junipero Sandstone	North-central Santa Lucia Range	Massive sandstone	Crushed and broken stone	None
Paleocene	Ep	Unnamed formations				
Cretaceous	Ku	Asuncion Group and undivided Upper Cretaceous rocks	Widespread in southern Santa Lucia Range and in Diablo Range	Massive sandstone	Crushed and broken stone	None
	Kl	Undivided Lower Cretaceous rocks	Limited exposures in southwest part of county and Table Mtn. area	Massive sandstone and conglomerate	Crushed and broken stone	None
Cretaceous(?)	gr	Santa Lucia granitic rocks	Widely distributed in Gabilan and northern Santa Lucia ranges; local along San Andreas fault zone	Weathered granitic rocks	Crushed stone	Many contractors—utilized as major source of road base
				Unweathered granitic rocks (uncommon)	Crushed and broken stone	Intermittent production of riprap (Atkinson deposit)
Cretaceous-Jurassic	KJf & KJfv	Franciscan Formation	Widespread in Diablo Range and southwest Santa Lucia Range	Massive sandstone, thinly-bedded chert, greenstone	Crushed and broken stone	Minor production of road construction materials (Mee Ranch) and riprap (Hill quarry)
Pre-Cretaceous	m	Sur Series	Widespread in Santa Lucia Range; limited in northern Gabilan Range	Gneiss, quartzite and other metamorphic rocks	Crushed and broken stone	None
	ls	Sur Series limestone	Common in Santa Lucia Range and northern Gabilan Range; local along San Andreas fault zone	Crystalline limestone and dolomite	Crushed and broken stone, dimension stone, special uses	Crushed rock (including roofing granules) produced at Natividad, Quail Creek, Sillacci and other deposits. Other quarries developed to supply lime kilns

Photo 44. Haldorn decomposed granite pit located near Carmel Valley on Las Laurelles Grade Road. Pits such as this have been utilized to a large extent as sources of base materials in road construction in Monterey County.

most easily-mined formations can be utilized for this purpose. The same applies to fieldstone, used locally for landscaping purposes and wall rock, as such material can weather out from many different types of rock units.

Crushed and Broken Stone

Virtually all types of broken, crushed and ground rock, with the exception of dimension stone and rubble, are considered herein as crushed and broken stone. This classification includes such products as riprap, bituminous and portland cement concrete aggregates, road base materials, imported borrow (fill), roofing and landscape granules, and various special materials (e.g. dolomite dust for marking athletic fields). The pits and quarries that are known to have yielded crushed and broken stone are listed in the Tabulation at the end of this report under Stone (crushed and broken), Stone (dimension), and Limestone and Dolomite.

Riprap consists of irregular fragments of broken stone which weigh as much as 35 tons and are placed without mortar to provide protection against the action of water. In Monterey County it is used in the construction of breakwaters and jetties in Monterey Bay and for protection of river banks, bridge abutments, railroad and highway embankments, dams, and spillways from the effects of water erosion. Unfortunately, the need for riprap is intermittent, the construction projects are somewhat scattered, the size and quality of the desired riprap vary widely, and good quality sources are not readily available. Consequently, commercial deposits have never been developed in the county. Most of the large stone riprap used by the U.S. Army Corps of Engineers for harbor and river projects has been imported from Logan Siding in San Benito County (quartz diorite), Brisbane in San Mateo County (Franciscan sandstone), and Rocklin in Placer County (granitic rock). Only the Monterey Harbor breakwater utilized some stone from a local source, the Atkinson quarry in the City of Monterey. Although the Atkinson granodiorite quarry is close to Monterey Bay and has yielded suitable large stone for harbor and river projects, it may be unavailable for future use as it is located in an urban area.

Most onshore projects require riprap of smaller dimensions than that of harbor projects. It is believed that most of the larger riprap stone used is imported, whereas the smaller stone is generally obtained from local sources. One of the few available local sources of riprap is the Hill quarry on the Little Sur River. Here, a very hard and durable sandstone of the Franciscan Formation has been produced for small stone riprap used as slope protection of State Highway 1. Also a small amount of partly weathered granodiorite from the Del Monte Properties Co. decomposed granite pit in sec. 25, T. 15 S., R. 1 W., was used as a source of riprap along the Salinas River. Other local material may have been used in highway, railroad, bridge, and dam protection, but specific sources are not known to the writer.

Santa Lucia granitic rock, when not weathered, is considered to be the best local source of riprap. However, virtually all exposures are deeply weathered and decomposed. Fresh exposures are relatively rare, generally in the bottoms of downcutting canyons where quarrying is expensive due to overburden. Two possible riprap sites are on the Bardin Ranch (NW¼ sec. 11, T. 15 S., R. 4 E.) and in San Jose Creek southeast of Point Lobos. Sometimes good riprap material is found at or just below the base of decomposed granite

pits, and these sites may offer the best sources for future supplies of broken stone. Other rock types that may provide suitable riprap include massive beds of indurated sandstone, volcanic flow rocks, greenstone, and crystalline limestone and dolomite (see Table 8).

The largest tonnage of crushed stone produced in Monterey County is used as base materials and imported borrow (fill) in road construction. For subbase and imported borrow, "decomposed granite" (highly weathered granodiorite or debris derived from it) is generally used, although virtually any easily mined material can be used as borrow provided the clay content is not too high. Decomposed granite is also used as bituminous paving in some secondary and private roads where traffic is not very heavy. On primary county and state roads, most decomposed granite has too low a shear value and is unsuitable for crusher run base and bituminous aggregate. However, less weathered decomposed granite deposits have been used in some places (see Tabulation at end of report). Other rock materials used include sheared and weathered chert and greenstone deposits (Mee Ranch pits) and crystalline limestone and dolomite cut by dikes of decomposed granite (Natividad and Sillacci quarries). Local sources of crushed gravel normally supply the needs for crusher run base, concrete treated base and bituminous aggregate (see in Sand and Gravel section). Crushed hornblende diorite imported from Logan Siding, San Benito County, frequently supplants locally derived stream gravel as a source of coarse aggregate in portland cement concrete pavements. Specifications for all road construction materials utilized by the state are given in California Division of Highways, Standard Specifications, Jan. 1960. County specifications probably are slightly lower, and there are no standard specifications for private road construction.

At the present time (1964), there is no commercial source of high-quality crushed stone aggregate in Monterey County. Potential sources for such material are generally the same as for riprap (see above). A unique but potential source of crushed stone is the tailings from the heavy media separation section of the Natividad dolomite plant of Kaiser Aluminum and Chemical Corp. This material, which consists of sound, slightly impure dolomite, is generally wasted.

Crushed stone used as roofing and landscape rock has been produced from crystalline dolomite at Natividad for many years and from limestone at Quail Creek in 1959–1960. These white materials are generally crushed to small sizes and used decoratively as roofing, driveway, walkway, and ground cover gravel (see section on Limestone and Dolomite for description of deposits). Special uses of dolomite include aggregate in concrete and terrazzo, marking for athletic fields, white fillers, and numerous other decorative, architectural, and industrial uses. White, crystalline limestone and dolomite from other sources probably could be developed for many of these uses.

Dimension Stone

Dimension stone is one of the first mineral commodities produced by organized methods in Monterey County. Mr. Harry Downey (oral communication, 1959), restorer of Carmel Mission, estimates that diatomaceous and siliceous shale and sandstone of the Monterey Formation were quarried by the Indians as early as 1790 for use in the seventh and last church at Carmel Mission. These quarries were located 1½ miles southeast of the mission on the present Palo Corona Ranch, on the steep south wall of Carmel Valley. Evidence of these quarries still can be seen. Siliceous shale and related rocks continued to be utilized in the construction of walls, steps, and archways of churches and homes through the nineteenth century, but it was not until 1924 that commercial production of dimension stone was first recorded. Since then, $442,880

Photo 45. Carmel Stone Quarry (Possodori), last operated by Dormady Equipment and Supply Co. in 1961, has supplied building stone since 1935. Stone consists of diatomaceous to siliceous shales and is quarried from four bed sequences of the Monterey Formation.

worth of siliceous, diatomaceous, and sandy shales of the Monterey Formation have been produced, almost all of which came from the Carmel Valley area.

Other types of rock utilized as dimension stone and rubble include crystalline limestone, lower Tertiary sandstone, and granodiorite. According to Aubury (1906, p. 73), very white, coarse-crystalline limestone rubble from the Spreckels quarry east of Salinas (probably NE¼ sec. 20, T. 14 S., R. 4 E.) was used as building stone in Salinas. Unpublished records show that the Spreckels quarry yielded 33,000 tons of crystalline limestone for rubble, and possibly riprap, from 1899 to 1903.

Gray and olive colored sandstone of Eocene or Oligocene age was utilized at one time as building stone in the construction of the Tassajara Hot Springs Hotel (Crawford, 1896, p. 636). The quarry site, which is located near the hotel, is too far from transportation facilities to be of commercial value.

According to park rangers at Point Lobos State Park, porphyritic granodiorite from Whaler's Cove also was quarried at an early date as a source of dimension stone.

Granodiorite fieldstone has been a popular building material for walls, fences and building foundations since about 1790. The practice of clearing stones from fields and lots still persists to some degree, and many fine examples of walls and other structures built of granodiorite fieldstones can be seen, especially in the Monterey Peninsula area.

Very similar to the above fieldstone is the granodiorite rubble obtained by Del Monte Properties Co. from their decomposed granite pit in sec. 35, T. 15 S., R. 1 W. The rubble represents less weathered "hard spots" in the deposit which are normally discarded if the size is too large to be crushed. Recently, the oversize material ranging in size from 7 to 15 inches has been sold as a by-product for use in the construction of walls and fences, either dry or with mortar. The brown iron oxide stains on the stone give walls and other low structures made from the rubble a rustic and pleasing appearance. The partially decomposed state of the granodiorite prevents its use in high structures, although a retaining wall at Pebble Beach made from this stone is probably about 10 feet high. The production of granodiorite rubble has never been recorded separately, but is included with decomposed granite production figures. Other types of fieldstone produced and sold on a small scale include serpentine, Franciscan chert and jasper. Such material is obtained from Franciscan terrane near Big Sur and elsewhere and sold for landscaping purposes. Production is not recorded.

In 1959–1960, there were only two operative dimension stone quarries, both being developed in siliceous shale of the Monterey Formation. The Carmel Stone quarry was last worked in 1961 after being active for many years. The Yost quarry near San Ardo was operated for only a short time in 1959. These quarries are described below; others are briefly summarized in the Tabulation at the end of this report.

Average yearly production of dimension stone from the Carmel Stone quarry has decreased from 2,235 short tons between 1950 and 1955 to less than 1,200 tons between 1956 and 1961. Production during the latter period became erratic, varying from 88 to 4,000 tons per year. Based on the continued popularity of Carmel Valley dimension stone in central California since the 1920's, it is likely that a steadier and assured supply of stone would increase demand for the stone by improving market conditions. The considerable variety in colors, shapes, textures and other physical properties of the Carmel Valley type stone previously produced from the Monterey Formation would permit this material to be adapted to many architectural applications. Additionally, substantial reserves of the various types of stone appear to be readily available at many quarry and potential quarry sites in the Carmel Valley area.

The most productive stone quarries in Carmel Valley, according to unpublished records, are the Carmel Stone quarry (Passadori), Santa Lucia Quarries, Sierra quarry, Carmel Stone quarry (Anthony) and Meadows Gulch quarry (?). Minor production has been obtained from the Stewart, Machado, and R. E. Meadow deposits (see Tabulation at end of report).

Carmel Stone (Passadori) quarry. Location: SE¼ sec. 16, T. 16 S., R. 1 E., M.D., 3 miles east of State Highway 1. Ownership: Dormady Equipment and Supply Company, Rt. 2, Box 940, Carmel.

This quarry was first developed in 1935 by A. L. Passadori, who reportedly obtained the property from Arthur Anthony, a former operator of a group of stone quarries about three-quarters of a mile to the northwest. After Mr. Passadori's death in 1956, Porter-Marquard Realty operated the quarry until May 1958 when Leo E. Alexander acquired the operation. Following Mr. Alexander's death, Mike Dormady of Dormady Equipment and Supply Co. began operating the quarry in 1960. Operations ceased in 1961 and the quarry was still inactive as of September 1963.

The Carmel stone quarry is located on a relatively low hill or spur that is underlain by fossiliferous, diatomaceous and siliceous shales (or silty mudstone) of the Monterey Formation. The beds range in thickness from less than an inch to 2½ feet and lie nearly horizontal. Depending on the thickness of the beds and the degree and type of jointing and fracturing, various types of flagging, veneer, building "block" and rubble (wall rock) are obtained from 4 different "ledges" (bed sequences). The following section generally describes the quarried ledges and wasted interledges:

Phata 46. Cormel Stone Quarry (Passadori). A (abave). After stripping overburden, ledge is broken by light blasting ond blocks ore removed with a pry-bor. B (below). Blocks ore then split, hand-trimmed and sorted according to size, shape, and physicol choracteristics.

Designation	*Description*	*Thickness*
Overburden	Fractured and weathered shale	5–10′
Ledge 1	Well-bedded, somewhat soft, porous, diatomaceous shale	5½′
Interledge	Thinly-bedded, fractured, siliceous shale	est. 15′
Ledge 2	Thinly-bedded, siliceous shale	4½–5′
Interledge	Thinly-bedded, fractured shale	est. 8′
Ledge 3	Single bed of hard, siliceous shale or porcelanite	2½′
Interledge	Thinly-bedded, fractured shale	est. 7′
Ledge 4	Well-bedded, hard, dense, siliceous shale	7′

The 4 ledges are worked by benching, the overburden and interledges being removed and wasted by bulldozing, ripping, and occasional blasting. Ledges are worked back as individual benches by light blasting of star-drilled holes spaced about 5 feet apart in a row 10 to 15 feet back from the face of the ledge. Commercial stone is obtained by prying large blocks loose, followed by hand splitting and trimming along joints and bedding planes. The different types of stone are hand sorted and either stacked in rectangular piles or placed in windrows. Waste rock is discarded in abandoned parts of the quarry.

Most of the stone is sold directly at the quarry but some is shipped to stone dealers as far north as the San Francisco Bay area. Prices charged for the different types of stone produced, f.o.b. quarry, as of 1959, were as follows:

Commercial Name	*Classification*	*Price/ton*
Small needle rock	Trimmed block	$25.00
Big needle rock	Trimmed block	32.50
Building block	Wallrock, rubble	25.00
Small patio stone	Flagstone, veneer	25.00
Large patio stone	Flagstone, veneer	32.50

Photo 47. Modern use of Carmel Stone is demonstrated in walls, chimney, and seawall of private home in Carmel. Seawall is uniquely shaped like the prow of a ship.

Special stones (hearth, mantle, and step stones) and fossiliferous ornamental stones sell at higher prices.

The present owner also sells ornamental garden stone (Sur Series metamorphic rocks, serpentine, and Franciscan chert) which is obtained from coastal streams to the south.

An average of 3 or 4 men are employed to operate the quarry and split the stone.

Stone previously obtained from several other quarries in the Carmel Valley area is described in detail by Galliher (1932, p. 21–27). These other quarry operations are summarized in the Tabulation at the end of this report.

Yost quarry. Location NE¼ sec. 11, T. 23 S., R. 9 E., M.D., reached by 4 or 5 miles of dirt road south of Garrissere Canyon Road. Owner: Harold Yost, King City, operated in conjunction with Bill Young, 419 N. 3rd St., King City.

The Yost quarry was first opened in 1959 as a source of informal, decorative building stone. It is developed in a sequence of argillaceous and semi-siliceous shale and mudstone of the Monterey Formation. The rocks are mainly poorly-stratified, somewhat laminated and highly fractured. Most of the stone sold apparently came from beds more than 4 inches thick. The rock is characterized by gray to yellowish-buff colors accented with brown iron oxide stains.

A narrow bench quarry about 200 feet along with a 5 to 8-foot face is developed in the gently dipping strata. Stone was obtained by light blasting and sledding down a 20-foot slope for hand sorting and loading onto trucks. Additional hand sorting, splitting and some sawing was done at San Lucas. It is reported that some of the stone was shipped to Los Angeles. Most of the material sold was used in King City by Bill Young, contractor, to construct home fireplaces and planters. The balance of the stone was stockpiled at San Lucas where the rough stone was priced at $25/ton and the sawed stone at $45/ton.

Although the stone is handsome in an informal way, its softness, slight fissility, and degree of fracturing would appear to prohibit its use in patios and steps and in high structures where bearing strength is important. When the quarry was visited in April 1960, it was inactive and no equipment remained at the site.

TUNGSTEN

Scheelite, calcium tungstate, has been reported from several localities in Monterey County, but no commercial concentrations are known. A scheelite prospect has been reported (Schmidt and Ortner, oral communication 1958) in NW¼ sec. 28, T. 17 S., R. 7 E., but the occurrence has not been verified. Bowen and Gray (1959, p. 13) noted a little scheelite in garnet-epidote tacite (skarn) "in sparse, small patches west of the barite prospects" (S½ sec. 34, T. 13 S., R. 4 E.) in the limestone masses on Fremont Peak. A piece of high-grade scheelite float was "reportedly found in the region of the headwaters of the Carmel River" (Fiedler, 1944, p. 248). A high-grade scheelite-bearing boulder was found along the Sur River in Big Sur State Park (Salem Rice, oral communication, 1962). Scheelite concentrates also were panned from stream deposits of the Sur River (O. P. Jenkins, oral communication, 1959).

Most of the tungsten mined in California has been obtained from tactite, a contact metamorphic rock formed in limestone or dolomite near the contact of granitic intrusive rocks. The most common minerals in tactite are reddish-brown garnet, green epidote, green pyroxene, quartz and calcite. Tactites commonly are the host rocks for tungsten minerals, as well

as minerals of copper, lead, molybdenum, and other metals. Such rocks have been observed in Monterey County and, although metallic deposits of commercial value have not yet been discovered, economic deposits may exist. Prospecting for tungsten should be concentrated near the contacts where Sur series carbonate rocks are intruded by granitic rocks in the Santa Lucia and Gabilan Ranges. Many of these limestone and dolomite masses are outlined on the geologic map (Plate I).

URANIUM AND THORIUM

Subsequent to the discovery of uranium in California, several areas of above normal radioactivity were discovered in Monterey County resulting in the location of numerous claims during 1954–1955. In spite of concerted prospecting effort, none of the prospects located could be developed into commercial production. The radioactivity that stimulated the bulk of the prospecting activity apparently was due to monazite (thorium-bearing phosphate of the cerium metals) in the Chews Ridge and Arroyo Seco areas and to radon gas in part of the Arroyo Seco area. These materials are not considered economic under the conditions in which they exist in Monterey County. However, monazite is a potential source of thorium and cerium metals when found in concentrations as a black sand in streams or other alluvial deposits. The only known occurrence of a common uranium mineral is at the Aronjo Ranch prospect where a subcommercial amount of yellow carnotite (hydrous vanadate of uranium and potassium) was found. Uranium was also noted in trace amounts in the oil of several bituminous sandstone deposits by W. J. Hail, Jr. (1957, p. 61–62, 66) (see Table 3).

Aronjo Ranch prospect. Location: SE¼ sec. 13, T. 23 S., R. 13 E., M.D., 6 miles west-northwest of Parkfield just north of Vinyard Canyon Road and east of Imusdale Cemetery. Ownership: Aronjo Ranch, Parkfield.

This prospect was discovered by Max A. Pennington of Atascadero, who leased some property from the Aronjo Ranch in 1954–1955. Here, carnotite occurs as thin coatings on fractures along a shear zone as much as 8 inches wide. The shear zone trends northwest and is in altered tuff within a sequence of nonmarine Miocene sediments which underlies the upper Miocene Santa Margarita Formation. A short adit and shallow shaft explore the prospect (M. C. Stinson, oral communication, 1960). There has been no production. Other uranium showings are reported to occur sporadically to the northwest over a distance of one or two miles, but there has been no development of these prospects.

Arroyo Seco area. Numerous claims were located in a continuous band along the Indians road by Western States Mining and Mineral Corporation, San Jose, in 1954–1955. These claims, which extended a distance of 6 airline miles along the Arroyo Seco-Indians road from NW¼ sec. 1 to SW¼ sec. 36, T. 20 S., R. 4 E., created considerable excitement for a while, but the ensuing minor development failed to reveal the existence of uranium minerals. M. C. Stinson of the California Division of Mines and Geology visited the claims at the north end of the group and determined that the radioactivity appeared to be mainly background, and probably was due to monazite associated with biotite distributed generally through granitic and metamorphic rocks. It is reported that prospecting interest was enhanced by the presence of radon gas which at times reached sufficient concentrations in the canyons to give high readings on detection equipment (M. C. Stinson, oral communication, 1960). Alex Campbell, the Regional Forester at King City, reported the last assessment work was done on these claims about 1957 (oral communication, 1960).

Chews Ridge area. A number of unpatented claims for uranium were staked about 1954–1955 near the lookout station on Chews Ridge and about 4 miles south of there. The claims were developed by shallow cuts and pits, but no uranium minerals were found. Radioactivity is due mainly to monazite distributed generally in the granitic and metamorphic rocks. One representative sample of monazite-bearing granitic rock analysed by the U.S. Geological Survey showed 0.01% U_3O_8 (M. C. Stinson, oral communication, 1960).

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Tabulation of Mineral Deposits In Monterey County

The following table is based on data obtained by the writer during his investigations of Monterey County, and on published and unpublished data believed to be authentic but not necessarily verified by the writer. Deposits visited by the author were investigated mainly during 1959 and 1960.

The mineral prospects and deposits are arranged alphabetically by mineral commodity. Synonyms for deposit names are given in parentheses after the preferred name and appear as cross references elsewhere in the table.

Deposits which are significant from an economic viewpoint and which can be located reasonably well are indicated on the map (Plate I); numbers corresponding to those on the map appear in the first column of the Tabulation. Location distances, unless otherwise qualified, are airline distances. In the "Owner" column, the date indicates when ownership data were obtained. References appear parenthetically in the last column and refer to the accompanying Bibliography. Only the last name of the author is given. This is followed by the last 2 digits of the publication date, a colon, and the page numbers of the references. Deposits noted "herein" after the reference listing are described in additional detail in the text, under the appropriate commodity headings.

ARSENIC

Map No.	Name of claim, mine, or group	Location	Owner (Name, address)	Geology	Remarks and references
	Riley Ranch prospect	Sec. 7(?), T. 15 S., R. 5 E., M.D., at head of Chualar Canyon 12 miles east of Chualar.	J. F. and J. T. Riley (1925)	At intrusive contact between crystalline limestone and granitic rock is mineralized zone showing arsenopyrite, magnetite, azurite and malachite.	Minor prospect developed by an open cut, short tunnel and 30-foot shaft. No known production (Laizure 25:28; Eric 48:275).

ASBESTOS

1	Burro Mountain......	S½ sec. 2 and SE¼ sec. 3, T. 24 S., R. 6E., M.D., 9 miles southwest of Jolon.	Asbestos Development, Inc., 1251 Ingraham St., Los Angeles (1954)		Prospect cuts in large serpentine mass. (Laizure 25:28; herein).
2	Table Mountain......	Sec. 30, T. 23S., R. 16 E., M.D. and vicinity, 8 miles east of Parkfield.	Johns-Manville Corp., 22 E. 40th St., New York (1963)	Reported to be similar to asbestos deposits northwest of Coalinga where short, matted fibers of chrysotile occur with talc in serpentine.	Asbestos prospects located and leased on south slope of Table Mountain. Developed by discovery pits; no production as of March 1963.
3	Willow Creek prospects	Secs. 30, 31, 32, T. 23 S., R. 5. E., M.D., near mouth of Willow Creek.	George Gaul, 5901 Montgomery Dr., Santa Rosa (1962)		Undeveloped prospects. (Herein).

BARITE

	Bardin..............	....	....	....	See Fremont Peak.
4	Fremont Peak (Bardin)	SE¼ sec. 34, T. 13 S., R. 4 E., M.D., 9 miles northeast of Salinas	Bardin Ranch..........	....	Productive 1916–1920. (Bradley and Logan 17:624–626; Boalich 21:156; Laizure 25:28; Bradley 30:52; Allen 46:75; Kundert 57:72, 73; Bowen and Gray 59:39–40; herein).

BITUMINOUS SANDSTONE

5	King City...........	Secs. 28, 33, 34, T. 19 S., and sec. 3, T. 20 S., R. 7 E., M.D., 4 miles west of King City	Not determined..........	Tar-impregnated sandstone of late Miocene age.	Undeveloped deposit. (Bramlette and Daviess 44: map; herein).
6	Mylar (San Lorenzo Creek)	SE¼ sec. 15, T. 19 S., R. 9 E., M.D., 9 miles northeast of King City.	George W. Rist, King City (?) (1960)	Bituminous sandstone overlying granitic rocks.	Developed by 2 quarries and several prospects; some production about 1890–1895. (Preston 93:259; Crawford 96:36; Eldridge 01:407–409; Waring and Bradley 19:596; Vander Leck 22:229; Laizure 25:28; Hail 57:61–62, 66; Jennings 57:61–62; herein).
7	San Antonio River....	SW¼ sec. 35, T. 24 S., R. 10 E., M.D., 6 miles southwest of Bradley.	Not determined..........	Bituminous sandstone overlying Monterey siliceous shale.	Minor development. (Goodyear 88:85–86; Crawford 94:29; Crawford 96:36; Elridge 01: 411–412; English and Kew 18:240; Waring and Bradley 19:596; Vander Leck 22:229; Laizure 25:28; Taliaferro 43:460; Hail 57: 62, 66; Jennings 57:61–62; herein).
8	San Ardo...........	Sec. 13, T. 22 S., R. 9 E., sec. 18, 19, 20, 29, 32, 33, T. 22 S., R. 10 E., M.D., 2 miles southwest of San Ardo.	Not determined..........	Bituminous sandstone overlying Monterey shale crops out over a distance of 5 miles.	Probably minor development. (Eldridge 01: 410–411; English and Kew 18:245; Bramlette and Daviess 44: map; Hail 57:62, 66; Jennings 57:61–62; herein).
	San Lorenzo Creek...	....	....	....	See Mylar.

CHROMITE

	Aldelabran..........	....	....	....	See South Slope.
	Daisy..............	....	....	....	See Slope Slope.
9	Evans Ranch prospect	NW¼ sec. 26, T. 24 S., R. 6 E., M.D.	W. J. and J. C. Evans (1953)	Residual chromite float overlying serpentine found within a 10-foot diameter area.	Prospect lies east of the Lilly group of chromite claims and is probably within the same serpentine body. No known development or production. (Walker and Griggs 53:54, 80).
10	Lilly group..........	N½ sec. 27, T. 24 S., R. 6 E., M.D., near south county border 2½ miles from ocean.	Monte Young, P.O. Box 43, San Simeon (1960)		Several unpatented claims at summit of northwest-trending ridge developed by open cuts. (Herein).
11	Mee Ranch..........	SW¼ sec. 9, T. 20 S., R. 11 E., M.D. on Cow Creek where crossed by State Highway 198	Mee Ranch, Peach Tree Valley (1959)	Placer deposit.	Small tonnage of massive chromite produced from boulders in creek. (Herein).

CHROMITE—Continued

Map No.	Name of claim, mine, or group	Location	Owner (Name, address)	Geology	Remarks and references
12	South Slope (Aldelabran, Daisy)	SW¼ sec. 29, T. 23 S., R. 6 E., M.D. on Hunter Liggett Military Reservation 7 miles east of Cape San Martin.	Joseph Holman, 1465 E. Orange Grove Ave., Pasadena (1959)	....	Unpatented claim; best chrome producer in County. (Logan 18:156; Walker and Griggs 53:53–54, 80; herein).
	Table Mountain chromite	Not determined.............	Not determined..........	Jet-black, massive chromite float found locally in large landslide.	Located west of the road up Table Mountain. No development (Logan 18:156; Laizure 25:29; Bailey 42:160).
13	Treasure Chest.......	NW¼ sec. 3, T. 24 S., R. 5 E., in Los Burros district.	Virginia Swanson, 230½ Soledad St., Salinas (1959)	Chromite float underlain by serpentine and Franciscan sandstone reported.	Unpatented lode claim previously owned by Frank Bigara; developed by 2 small cuts in serpentine. Small amount of chromite float milled and concentrates shipped in 1957. Concentrate was high grade containing 50.6% Cr_2O_3 with Cr/Fe ratio of 2.7. Idle 1959.

CLAY

14	Arca Roofing Tile Plant	1 mile east (southeast?) of Castroville. Probably near SW¼ sec. 34 (proj), T. 13 S., R. 2 E., M.D.	Not determined..........	18-foot thick layer of yellow, plastic clay overlain by 1 foot of black adobe (Dietrich 28:130–131, 324).	Joe Arca operated a roofing tile plant and clay pit here from 1924 to about 1928 (Dietrich 28:130–131). Unpublished records show that Salinas Valley Clay Products (1929–1931) and Castroville Clay Products (1931–1937?) also operated near Castroville. These operations may have utilized the same clay pit.
	Carmel Building Specialties Co.	....	....	....	See Rancho del Monte.
	Castroville Clay Products	Not determined.............	Not determined..........	....	A company by this name produced clay, possibly near Castroville, intermittently from 1931 to 1937. May be a continuation of the Arca Roofing Tile Plant (which see)
	Echstine...........	T. 24 S., R. 8 E., M.D. (sec. not determined).	Not determined........	....	Deposit of whitish-gray, plastic clay that fires to a red color has been noted on the property of Mrs. G. P. Echstine of Pleyto. The deposit has poor accessibility, 18 miles from a railroad, and probably not commercial (Dietrich 28:132). (Also Laizure 25:29).
15	Heins Lake.........	Sec. 2, T. 15 S., R. 3 E., M.D., 2 miles southeast of Salinas.	Not determined..........	Blue clay at the bottom of Heins Lake (dry) reportedly covers about 300 acres and averages 4 feet thick (Laizure 25:29). This material has been classified as Dublin clay adobe soil which is sometimes calcareous and contains 32% clay, 39–54% silt, and the rest sand (Carpenter and Cosby 25:70).	Deposit apparently never developed and probably under cultivation. Considering it's composition and potential surface development, it would not seem to offer commercial possibilities as a clay source. (Laizure 25:29; Dietrich 28:132).
	Jens..............	Not determined.............	Not determined..........	....	J. C. Jens, under the name Mineral Earths Supply Co., shipped several 1,000 tons of clay 1911–1913 and fullers earth 1910–1914 from a deposit (deposits?) east of Chualar. (Waring and Bradley 19:596; Boalich, et al 20:65; Laizure 25:29; Dietrich 28:132).
	Mineral Earths Supply Co.	....	....	....	See Jens.
	Monterey Mission Tile	Approx. sec. 5, T. 16 S., R. 2 E., M.D.	Not determined..........	10 feet of black adobe covered with 2 feet of soil.	This deposit, and possibly others near Seaside, were used by Monterey Mission Tile as a source of clay from 1924 to 1928. (Laizure 25:57; Dietrich 28: 131–132, 137; herein).
16	Rancho del Monte....	Sec. 3, T. 17 S., R. 2 E., M.D., in Carmel Valley near airport.	John B. Simpson, P.O. Box 64, Carmel Valley	Adobe soil derived from terrace deposit.	Material used to make adobe brick in early 1940's (Fiedler 44:249). Hans Sumpf of Fresno reportedly made adobe bricks in late 1940's and early 1950's. Present owner experimented with brick manufacture about 1955, but the operation was not commercial. (Herein, under Adobe in Clay Section).
17	Salinas Brickyard.....	Salinas. Probably NE¼ sec. 4, T. 15 S., R. 3 E., M.D.	Not determined..........	Layer of clay 10 feet thick of which the bottom 4 feet is plastic; exposed in creek.	In the early 1900's, S. Pierce operated a brickyard and clay pit at the south end of Abbot Creek near a cemetery. Bricks were hand made, air dried and burned in open kilns (Aubury 06:250; Boalich et al 20:65; Laizure 25:29). Production was intermittent from 1898 to 1910.
	Salinas Valley Clay Products	Not determined.............	Not determined.........	....	A company by this name produced a small amount of clay from 1929–1931 near Castroville. Possibly same pit or plant as Arca Roofing Tile (which see).
18	Sawmill Gulch.......	W½ sec. 26, T. 15 S., R. 1 W., M.D., south of Pacific Grove	Del Monte Properties Company, 620 Market St., San Francisco (1959)	Sandy clay from shallow Quaternary clay deposit in Sawmill Gulch.	Fletcher Olmstead erected brick works in Sawmill Gulch 1¼ miles from Moss Beach in 1947 in an attempt to produce adobe bricks. Probably less than 1,000 bricks were produced before the operation was abandoned. The bricks were reported to be satisfactory, but the operation was not economic due to slow drying at this cool coastal site. Some of the adobe bricks were used to line the charcoal kilns of Del Monte Properties Co. The kilns are still used.

COAL

Map No.	Name of claim, mine, or group	Location	Owner (Name, address)	Geology	Remarks and references
19	Carmel (Carmelo)	E½ sec. 1, T. 17 S., R. 1 W., M.D., 5 miles south of Carmel	Not determined		Deposit developed intermittently from 1874 to about 1901, modest production. (Irelan 88:404, Angel 90:347–348, Crawford 90:54, Laizure 25:30, Trask 26:152–153, herein).
	Carmelo				See Carmel.
	Monterey Coal Co.				See Priest Valley prospects.
	Pacific Clay and Coal Co.				See Priest Valley prospects.
20	Priest Valley prospects	Sec. 17 and 21, T. 20 S., R. 12 E., M.D., 19 miles east of San Lucas	Not determined		Minor development by Monterey Coal Co., Pacific Coal and Clay Co., and others. Little or no production. (Irelan 88:404, Crawford 94:59, 60, Crawford 96:54, Pack and English 14:159–160, Waring and Bradley 19:597, Laizure 25:30, herein).
21	Stone Canyon	Sec. 14, T. 22 S., R. 13 E., M.D., 18 miles northeast of Bradley	Dorthy M. White, Miami, Florida (1961)		Discovered in 1870 and developed intermittently until 1935, substantial production. (Goodyear 88:172–173, Irelan 88:403–404, Crawford 94:59 Crawford 96:54, Arnold 06:223–225, Campbell 07:435–438, Campbell 11:243–247, Parker 11:102–103, Ford et al 13:53, 396, Thiessen 13:245–248, White 13:37–39, Pack and English 14:156–157, Waring and Bradley 19: 597–598, Boalich 21:156, Hamilton 22:9–10, Laizure 25:30–31, Cooper, et al 47:36–37, Corps of Engrs. 51: A–15, A–19, Jennings 57:157–158, herein.)

COPPER

Map No.	Name of claim, mine, or group	Location	Owner (Name, address)	Geology	Remarks and references
22	Bedell	Sec. 21, T. 23 S., R. 15 E., M.D., 4 miles northeast of Parkfield	L. E. Bedell, Parkfield (1924)	Oxidized copper minerals in serpentine	Undeveloped prospect. (Waring and Bradley 19:598, Laizure 25:31, Eric 48:275).
23	Chualar	Secs. 10, 11, 14, 15, 22, 23, T. 15 S., R. 5 E., M.D.	c/o Claude C. Kline, 1446 Washington St., San Francisco (1943)	Two mineralized zones 8–14 feet thick and over a mile long, in quartzite, granite and limestone. Assays said to range from 1.67 percent to 19 percent copper.	Developed by 300-foot adit and 90-foot shaft. No known production. (Eric 48:275). Prospect was noted at least as early as 1879 (Min. and Sci. Press, 1879, v. 38, n. 13, p. 197).
	Grizzly				See under Gold.
	Hammond				See under Gold.
	Lucky Moe				See under Gold.
24	Native Copper	Near N¼ cor. sec. 26, T. 23 S., R. 15 E., M.D., 6 miles east of Parkfield on Table Mtn.	Not determined (Native Copper Co., Coalinga in 1924)	Shear zone in serpentine containing chalcocite and specks of native copper.	Developed by prospect adits. No known production. (Waring and Bradley 19:598, Laizure 25:31, Bailey 42:160, Eric 48:275).
	New York				See under Gold.
	Riley Ranch				See under Arsenic.
25	Trampa Canyon	Approximately SE¼, sec. 34, T. 17 S., R. 3 E., M.D., on south side of Tularcitos Ridge	Not determined	Chalcopyrite and pyrite occur in mineralized zone in Sur Series marble near contact with Santa Lucia Quartz Diorite.	Prospect in Trampa Canyon, 1000 feet north of ranch house, once mined for copper, enterprise abandoned about 1931, apparently because of low-grade ore. No record of production. (Fiedler 44:247).
26	(Unnamed)	SE¼ sec. 2, T. 23 S., R. 14 E., M.D., 4 miles north of Parkfield	Not determined	A one-foot wide vein containing chalcopyrite and possibly other sulfides, cuts Franciscan rocks.	A few hundred feet south of the G.W.D. mercury prospect. No known development. (Bailey 42:160).

DIATOMITE

Map No.	Name of claim, mine, or group	Location	Owner (Name, address)	Geology	Remarks and references
	Alm	Not determined	Not determined		Unpublished records show Effie Alm produced a minor amount of diatomite near Bradley (possibly at or near the Jens deposit) in 1918.
	Buttle	Not determined	Not determined		William Buttle in 1918 and Buttle Products in 1928 produced small amounts of diatomite (unpublished records), deposit not identified in field.
27	California Kieselguhr Co.	E½ sec. 15, T. 24 S., R. 10 E., M.D., 4 miles west of Bradley	G. A. Stonsifer, and Dicalite Division Great Lakes Carbon Corp., 612 S. Flower St., Los Angeles (1959)		The California Kieselguhr Co. operated this deposit 1922–1928. Pacific Diatom Products Co. operated same deposit 1927–1942. (Laizure 25:32–33, 36, herein.)

DIATOMITE—Continued

Map No.	Name of claim, mine, or group	Location	Owner (Name, address)	Geology	Remarks and references
28	Great Lakes Carbon Corp.	Parts of secs. 9, 10, 15, 23, T. 24 S., R. 10 E., M.D.	Dicalite Division Great Lakes Carbon Corp., 612 S. Flower St., Los Angeles (1959)	....	This company controls interest in much of the diatomite along the southwest side of Hames Valley. (Herein.)
29	Jens...............	SW¼ sec., 20 T. 23 S., R. 10 E., M.D., 6 miles northwest of Bradley	Violet E. Alton, Pasadena (1959)	....	Substantial production from 1909 to 1921. (Waring and Bradley 19:598–599; Laizure 25:33; Bramlette 46:14; herein.)
30	King City deposit....	Sec. 28, 33, 34, T. 19 S., and sec. 13, 14, 24, T. 20 S., R. 7 E., M.D., 3 miles west of King City	Not determined..........	....	Undeveloped diatomite deposits. (Weidman 58:93–95, 202, P1. 1A; herein.)
	Monterey Products Co.	....	....	....	See Work Ranch.
31	Oakdale Ranch......	Sec. 18, T. 24 S., R. 9 E., M.D., 3 miles west of Pleyto	Not determined..........	Cream colored diatomite of apparent high grade exposed on 4 hills, but probably less pure than diatomite of Hames Valley. Analyses show 83.61% SiO_2, 4.70% Al_2O_3, 1.19% Fe_2O_3. (Laizure 25:35–36.)	Not developed. Owned by A. B. Ford, Pleyto and G. D. Ford, Ogden, Utah in 1925. (Laizure 25:35–36.)
	Pacific Diatom Products Co.	....	....	....	See California Kieselguhr Co.
32	Riewerts............	SE¼ sec. 9 (?), T. 24 S., R. 10 E., M.D., 5 miles west of Bradley	Dicalite Division, Great Lakes Carbon Corp., 612 S. Flower St., Los Angeles (1959)	....	Small amounts of diatomite produced intermittently by B. J. Riewerts 1906–1923. (Aubury 06:292; Laizure 25:36; herein.)
33	Work Ranch.........	NW¼ sec. 2, T. 16 S., R. 1 E., M.D., 2½ miles southeast of Seaside	T. A. Work and/or Saucito Land Co., (Saucito Rancho) (1959)	....	Deposit operated by Monterey Products Co. from 1923 to 1931. The product was sold under the name "Calatom". (Laizure 25:33–35; herein.)

FELDSPAR

Map No.	Name of claim, mine, or group	Location	Owner (Name, address)	Geology	Remarks and references
	Bardin..............	Not determined.............	Not determined..........	....	Undeveloped feldspar deposit reported 7 miles east of Salinas on property of H. Bardin. (Boalich 21:156; Sampson and Tucker 31:420.)
(116)	Del Monte Properties Co.	Near E¼ cor. sec. 34, T. 15 S., R. 1 W., M.D., opposite Fan Shell beach	Del Monte Properties Co., 620 Market St., San Francisco (1960)	Feldspathic dune sand..........	Company processes dune sand from Fan Shell Beach area at their sand plant, 1 mile southwest of Pacific Grove. Feldspar product is a mixture of potash feldspar and sodalime feldspar, which has been produced since 1952. (Wright 57:196, 197, 199; herein.) (Also see under Sand and Gravel.)
34	Jens...............	NW¼ sec. 34, T. 15 S., R. 5 E., M.D., 6 miles east of Chualar	Stauffer Chemical Co., 420 Montgomery St., San Francisco (1960)	....	Potash feldspar deposit operated 1907 to around 1920 by J. C. Jens under the name Mineral Earths Supply Co. Also operated in 1920 by G. W. Elder of San Francisco. (Waring and Bradley 19:601–602; Boalich 21:156; Laizure 25:36–37; Sampson and Tucker 31:420; Wright 57:196, 197; herein.)
35	Johnson Ranch prospect	SE¼ sec. 28, T. 15 S., R. 5 E., M.D., 6 miles east of Chualar	Frank Johnson, et al., Chualar (1960)	Potash feldspar occurs in pegmatite and coarsely-crystalline granitic rock outcrop on hill south of Chualar Canyon. Feldspar does not appear to be of commercial value at present as it is too intergrown with quartz and other minerals to be handcobbed	Slightly prospected many years ago by the Johnson family. No production. (Laizure 25:37; Sampson and Tucker 31:420.)
	Tonge..............	Not determined.............	Not determined..........	....	Undeveloped feldspar prospect reported to occur on the Jenny Tonge property near the Jens deposit. (Sampson and Tucker 31:420.)

GEM STONES

Map No.	Name of claim, mine, or group	Location	Owner (Name, address)	Geology	Remarks and references
36	Cape San Martin (Jade Cove)	W½ sec. 19, NE¼ sec. 31, T. 23 S., R. 5 E., M.D.	Not determined..........	Nephrite jade—found in place and as beach gravel	An important collecting locality for many years. (Crippen 51:3–14; Wright 57:212; Ames 57:4–5; Mohler 57:7; herein.)
	Jade Cove..........	....	....	....	See Cape San Martin.
	Limekiln Creek.......	Sec. 22, T. 22 S., R. 4 E., M.D., 1½ miles southeast of Lucia	Not determined..........	Rhodonite with black manganese oxide. Reported to occur in place and as boulders at the mouth of Limekiln Creek	Collecting locality for lapidary material. (Herein.)
37	Stone Canyon jasper deposit	Sec. 16 (?) T. 22 S., R. 13 E., M.D., 16 miles northeast of Bradley	Mrs. Hope Bagby, Hidden Valley Ranch, San Miguel (1960)	Brecciated jasper cemented with chalcedony	A well known collecting locality for lapidary material. (Sperisen 38:49; Rowe 56:44,46; herein.)

GOLD

Map No.	Name of claim, mine, or group	Location	Owner (Name, address)	Geology	Remarks and references
	Adair	Not determined. (Los Burros district)	H. C. Clair, Santa Cruz (1940)		U.S. Bureau of Mines records show a production of 3 ounces gold and 5 ounces silver in 1940 by H. C. Clair; 5 tons of ore concentrated to 1 ton.
38	Ajax	NE¼ sec. 1, T. 24 S., R. 5 E., M.D., Los Burros district, just south of Mariposa claim.	Not determined	Small, irregular veins of quartz and calcite in Franciscan sandstone, all of which is crushed. Vein matter on dump appears barren, except for some vugs and minor sulfides.	Unpatented claim located June 1887 by a man named Fancher. Developed by a 219-foot tunnel and a 21-foot crosscut 146 feet from portal where vein 3–4 feet thick encountered (Irelan 88:409). Ore was reportedly shipped to a mill at Mansfield in 1903, but there is no record of production. Claim probably was relocated in part as the Ora F No. 1 prior to 1908. Workings cleaned out a little in late 1930's, but idle and inaccessible in 1959.
39	Alice Quartz	S½ sec. 35, T. 23 S., R. 5 E., M.D., adjoins Buclimo to the southeast.	Howard Hilton, Los Burros, Virginia Swanson, Salinas, and H. Stevens (1959)	Small quartz veins trending N. 60° W. (?) in crushed Franciscan sandstone.	Lode claim located in 1889 and patented 1892. Developed by 2 short adits and a shaft. One tunnel, sealed off with concrete, serves as a water supply for Melville claims to the northwest; other workings reported to be inaccessible. Apparently some production between 1889 and 1892, but records do not verify. Idle 1959.
40	Ancona (Brewery)	SE¼ sec. 34, T. 23 S., R. 5 E., in Los Burros district on north side of Willow Creek road.	Art Sherman and Archie Hammond, 1015 Shell St., Pacific Grove (1959)		Old lode claim intermittently developed 1887–1959. (Irelan 88:409; Waring and Bradley 19:603; Hill 23:328; Laizure 25: 38; Franke 35:463; Engrg. & Min. J. 58: 31–32; herein).
	Bauman claims	NW¼ sec. 3, NE¼ sec. 4, T. 24 S. and SE¼ sec. 33, T. 23 S., R. 5 E., M.D., in Los Burros district on south fork of Willow Creek.	Multiple ownership (partly on homestead properties of Lon Phillips of Coalinga and Les Byers) (1959)	Three-foot vein of black talc and quartz with slate and sandstone hanging wall and slate footwall reported. (Franke 35:464)	Beginning in 1931, this group of claims (Substantial, Providence, Existence placer claims; Olivine, One Dollar, Prince Bismark lode claims) developed by a 200-foot adit and 16-foot drift (Olivine claim) and a 110-foot tunnel with crosscuts 76 and 50 feet long (Providence claim). (Franke 35:464). Claims are a relocation in part of the Spruce Creek placer deposits (which see). Idle 1959.
	Benn and Smith claims	Sec. 27(?), T. 23 S., R. 5 E., M.D. on Willow Creek.	Not determined		2 placer claims reportedly located near confluence "north and south forks" of Willow Creek in 1934 (Franke 35:463). Also see Rocky Bar.
	Big Sandy Creek	Not determined	Not determined		Gold reportedly mined from placers on Big Sandy Creek near Slack's Canyon (Angel 90:345).
	Black Crystal	Sec. 3 or 4, T. 24 S., R. 5 E., M.D., Los Burros district.	Not determined	Serpentine and Franciscan sandstone (?).	Early lode claim extensively prospected without success by Moor Bros. and Company after finding placer gold in gulch below (Irelan 88:408).
	Blackberry				See Plaskett.
	Blanco (or Blanch?) McNeil				See Plaskett.
	Blue Jay				See Manchester (also Blue Jay No. 1)
41	Blue Jay No. 1	NE¼ sec. 2, T. 24 S., R. 5 E., M.D., Los Burros district.	W. & R. Pugh, Rte. 1, Box 92, Soledad, and John Lazier (1959)	Franciscan sandstone near adit badly crushed and contorted, but roughly strikes east-west and dips 45° N. Dump material consists of vein quartz associated with calcite in sandstone and slaty gouge. Mineralization appeared limited to a few minor specks of arsenopyrite (?).	South of the Mary S Extension and north of the Blue Jay No. 2. Developed by an adit driven north and now caved. Previously worked by S. M. Pugh, but there is no record of production. However, past proudction suggested by presence of 5-stamp mill located a few 100 feet south of adit on Blue Jay No. 2. Idle 1959. Claim is a relocation, of the south part of the Manchester (which see). Also reported to be part of the Mariposa (which see). (Waring and Bradley 19:605).
	Blue Jay No. 2				See Blue Jay No. 1
	Boos	Not determined	Not determined		Unpublished records show that G. E. Boos of Jolon produced 55.5 ounces of placer gold in 1902, but the location of the deposit is not known. The gold had a fineness of 871.
	Boynton	Not determined	Not determined		A specimen of auriferous chalcopyrite and pyrite in quartz is on display at the Mineral Exhibit (Monterey County case) of the California Div. of Mines and Geology in San Francisco. The gold specimen (No. 120) is stated to be from the Boynton mine near Soledad and was donated by U. Boynton about 1880. No other record of the Boynton mine is known.
	Brewery				See Ancona.
	Brooklyn	SE¼ sec. 36, T. 23 S., or NE¼ sec. 1, T. 24 S., R. 5 E., M.D., Los Burros district.	Not determined	Franciscan sandstone and "slate" cut by stringers of quartz bearing free gold.	Developed by open cuts; no record of production; idle many years. Lies parallel and adjacent to the New York claim. Claim was relocated as the New Deal in 1934 by William Cruikshank. (Waring and Bradley 19:603; Laizure 25:38; Franke 35:463).
	Brown Eagle Nos. 1, 2 and 3	Not determined	Philip Krieger (1925)		Claims located about 1923. (Laizure 25:41).
42	Buclimo (Last Chance; Cruikshank)	SE¼ sec. 35, T. 23 S., R. 5 E., M.D., Los Burros district.	Buclimo Mining Co., c/o Rudolph Ernst, 1361 7th Ave., San Francisco (1959)		The most important gold mine in Monterey County; presently consists of the patented Last Chance, Mary S, Mary S Extension, West Extension, Pansy Fraction, East Extension and Pine claims and the unpatented Perry and Ora F No. 2 claims. Significant development and production confined to the

GOLD—Continued

Map No.	Name of claim, mine, or group	Location	Owner (Name, address)	Geology	Remarks and references
	Buclimo (Last Chance; Cruikshank)—Cont.				Last Chance claim (see Buclimo herein) and Ora F No. 2 (See Grizzly herein). (Irelan 88:405–407; Preston 93:260, 261; Crawford 94:184; Crawford 96:234; Davis 12:697–698; Waring and Bradley 19:603–604; Hill 23:327–328; Laizure 25:39; Franke 35:463).
43	Bushnell(Green Gold; Yellow Quartz)	S½ sec. 22, T. 23 S., R 5 E., M.D.	Stewart Kinder, Los Burros, c/o Big Sur (1962)		Lode mine consisting of 3 unpatented claims. Discovered about 1904 and developed intermittently since then. Minor production recorded 1912 and 1935; larger production reported. Active 1962. (Hill 23:326; Laizure 25:39; Franke 35:463; herein).
	Bushness	Not determined	Not determined (was John Bushness (?) 1919).	Quartz vein in "slate"	Discovered in 1911 (Davis 12:698). Located on "Spruce" Creek; developed by 50-foot tunnel and one-stamp mill (Waring and Bradley 19:604). Probably misspelling of Bushnell (which see).
44	Calizona	S½ sec. 17, T. 24 S., R. 6 E., M.D., lies on west bank Salmon Creek.	Gerald Doyle, Watsonville (1959)		Old placer claim said to have been worked around 1900. 10-inch pipe reported on claim indicates gravel or soil debris may have been sluiced. No production known. Previously located by John Evans. Accessible by trail only.
	Carmel River area				See introductory text to Gold section (herein).
	Charleston (Grand Pacific)	SE¼ sec. 35, T. 23 S., R. 5 E., M.D., Los Burros district.		15-inch quartz vein dips 70° W. at surface, but narrows to 4 inches and changes direction below surface.	Discovered in 1887 and worked until about 1893. Developed by 50-foot shaft and other workings (Irelan 88:407–408; Preston 93:260). In 1889, a tunnel to drain this mine was begun, but never completed. This claim is partly relocated as the Pansy Fraction (see Buclimo).
45	Cholame Grant (Gold Hill area)	Sec. 21 and 22, T. 24 S., R. 15 E., M.D., 7 miles southeast of Parkfield	Howard Jack, Cholame Ranch (1960)		Gravel deposits in a series of gulches have yielded some placer gold at "Gold Hill" (Waring and Bradley 19:606; Laizure 25:42; herein, under introduction to Gold section).
	Condor Group	S½ sec. 35, T. 23 S., R. 5 E., M.D., Los Burros district.	Not determined. (was Wm. McPhie, 1935)		4 unpatented claims (Condor and others) adjoining the Melville group and Alice claim to the north; mentioned by Franke (35:463). Reportedly developed by a 100-foot adit. Previously known as the New Era; recently relocated as the Lucky Moe (which see) and other claims.
46	Cool Springs	NE¼ sec. 1, T. 24 S., R. 5 E., M.D., Los Burros district	William Krenkel, Jolon (1959)	Sheared Franciscan sandstone cut by veins of quartz reported to contain free gold.	Unpatented lode claim located in 1900. Reportedly developed by a 200-foot adit driven southeast and a 40-foot inclined shaft, both caved; a 120-foot adit driven to east was blocked by an ore car at time of visit. James Krenkel and S. O. Pugh milled some ore in an arrastra in 1902, but no production recorded. However, minor production of gold made in 1906 and 1907 under the name Cold Springs. Idle 1959. (Also see Oregon).
	Cruikshank				See Buclimo.
	East Extension No. 1 (North Extension)	SE¼ sec. 35, T. 23 S., R. 5 E., M.D.	Buclimo Mining Co., San Francisco (1959)		Patented lode claim now part of the Buclimo mine (which see). A relocation of the North Extension, which was mentioned by Preston (93:260).
	Evergreen Placer	Not determined	Philip Krieger (1925)		Claim mentioned by Laizure (25:41). No known development.
	Existence				See Bauman claims.
	Fighting Bob No. 1	Approximately S½ sec. 22, T. 23 S., R. 5 E., M.D.	Abel A. Collins, Salinas (1925)		Listed by Laizure (25:41). No known development or production.
	Gilbert	Probably sec. 21, T. 23 S., R. 5 E., M. D.	Not determined		A specimen of auriferous pyrite and arsenopyrite in quartz from this claim is on display at the Division of Mines Mineral Exhibit (Monterey Co. case), San Francisco. The exact location of this claim is not known, but F. K. Gilbert had claims in sec. 21 and 22, T. 23 S., R. 5 E., during the 1930's, which are probably now relocated (see Logwood or Goodrich). Philo Fritz who donated the specimen (No. 20694) in August 1936, also is known to have located claims in sec. 21.
47	Gillis claims	SE¼ sec. 33, T. 23 S. and NE¼ sec. 4, T. 24 S., R. 5 E., M.D.	Situated on homestead land owned by Lon Phillips, Coalinga (sec. 33), and Les Byers (sec. 4) (1959).	Franciscan rocks and serpentine cut by thin quartz veins and overlain by minor gravel and talus along "Spruce" (South Fork of Willow) Creek.	Franke (35:463) mentions that J. C. and Raymond Gillis worked placer ground on "Spruce" Creek in early 1930's. Records show that F. J. Gillis produced 3 ounces of placer gold in 1933 from his Nugget Gulch claim. In 1935 and 1939, 5.3 ounces of placer gold were produced on the same claim or nearby from "bench" gravels along the creek by J. C. Gillis and H. B. Krenkle. Development in this vicinity consists of minor pits in talus along the creek, where virtually no gravel was observed. Nearby, to the north are 3 short adits driven northeasterly into sandstone or serpentine. Only the most easterly adit appears to have encountered quartz veins, and these were thin and non-mineralized. (Also see herein, under Spruce Creek)

GOLD—Continued

Map No.	Name of claim, mine, or group	Location	Owner (Name, address)	Geology	Remarks and references
	Gold Hill area				See Cholame Grant.
	Gold Ore No. 2	Sec. 35, T. 23 S., R. 5 E., M.D., Los Burros district.	Not determined	Franciscan Formation cut by small vein carrying free gold.	Developed by a 67-foot adit (Laizure 25:41). Relocated by a Mr. Henderson of Paso Robles (Franke 35:464). No known production.
48	Goodrich	W½, sec. 21, T. 23 S., R. 5 E., M.D.	Marty Hess, Los Burros, c/o Big Sur (1959)	Mainly Franciscan sandstone, locally sheared. Owner reports vein quartz and bluish fault gouge carries free gold associated with sulfides in accessible adit.	Claim located about 1900 by John Bushnell and later owned by Fred Stalter. Workings consist of 3 adits, 2 of which were driven westerly and are now caved. A third tunnel extends 320 feet toward the south and is accessible. No record of production, but some gold reportedly produced shortly after 1900. The claim adjoins the Queen Hattie to the south.
49	Gorda	NE¼ sec. 4, T. 24 S., R. 5 E., M.D., on south fork Willow Creek.	Les Byers (1959)		Apparently located just east of the Gillis claims, this mine was worked in 1908 by Gorda Mining Co., yielding 40 ounces of gold and 11 ounces of silver. Small lode gold production by the Ralston Mining Co. in 1907 may have come from this same mine (see Spruce Creek placer). The workings were not definitely located and are probably caved. Waring and Bradley (19:604–605) state the mine was developed by a 50-foot drift with a 20-foot raise at the end in loose Franciscan sandstone, along the south side of the Creek. (Davis 12:697; Hill 23: 328–329; Laizure 25–39; Franke 35:463).
	Grand Pacific				See Charleston.
	Great Ruby Gold Mining Co.	Not determined	Not determined		Unpublished records show that the Great Ruby Gold Mining Co. of Jolon produced 6 ounces of gold and 4 ounces of silver from a lode mine in Monterey County in 1910.
	Green Gold				See Bushnell.
50	Grizzly (Ora F No. 2)	SW¼ sec. 36, T. 23 S., R. 5E., M.D.	Buclimo Mining Co., 1361 7th Ave., San Francisco (1959)		Old lode claim; productive 1890, 1902–04. (Crawford 94:184; Hill 23:327; herein.)
	Hammond claims	Approximately NW¼ sec. 35, T. 23 S., R. 5 E., M.D.	Not determined	Franciscan sandstone and slate (?) mineralized by pyrite and chalcopyrite along fracture zones trending N 80° W (Hill 23: 326, 328)	Claims prospected by F. C. Hammond in 1920; developed by surface cuts (Hill 23:326, 328). Relocated by H. Melville prior to 1935 (Franke 35:463); probably now part of the Melville (which see.)
	Holly-Berry				See Plaskett.
	Howard				See Plaskett.
	Humbug	Near N¼ cor. sec. 27, T. 23 S., R. 5 E., M.D.	Fred Vaughn, c/o Gorda Station, Big Sur (1959)	Recent stream gravel	Placer claim located at the confluence of North Fork Willow Creek and a north tributary. Probably a relocation of the Plaskett placer (which see). It is reported that after the old Plaskett cabin burned about 1955, the present owner worked the gravels upon which the cabin was situated and produced some gold, including a nugget worth $600. There is no record of production for this claim and the nugget is said to have been kept as a specimen.
	Jolon	Not determined	Not determined		Unpublished records show that a minor amount of lode gold and silver was produced in 1912 by C. Turner. The gold was reportedly obtained from 50 tons of free-milling ore.
	Jolon area				See introduction to Gold section (herein).
	Kenner claim	Sec. 27(?), T. 23 S., R. 5 E.	Wm. and Templeton Kenner (1934)		Lode claim located in 1934 near the confluence of the "north and south" forks of Willow Creek (Franke 35:463). No known production or development.
	King	Near NW corner sec. 1, T. 24 S., R. 5 E., M.D.	Not determined	An 18-inch vein of quartz striking northwest and dipping 40° in "slate" and sandstone (Preston 93:262).	Developed by 2 adits driven north, 100 and 150 feet long, and 3 shafts, the deepest being 130 feet and inclined. The quartz ore was crushed in a 12-foot diameter arrastra. No record of production. (Irelan 88:409; Preston 93:262, map; Waring and Bradley 19:605). Apparently relocated about the turn of the century partly as the McKinley (see Mariposa), Ora F No. 2 (which see) and Perry.
	Last Chance				See Buclimo.
	Lilac				See Plaskett.
	Lodi	NW¼ sec. 1, T. 24 S., R. 5 E., M.D.	Paul Acquistapace, Los Burros, c/o Big Sur (1959)	Franciscan sandstone, which strikes northeast and dips 40° SE; cut by veinlets of quartz and calcite which appear to be nonmineralized	Workings consist of an adit 150 feet long, driven southeast since 1937, and 2 inaccessible adits 50 and 100 feet long. No known production. Claim is reported to be a relocation in part of the McKinley (see Mariposa) and before that the King (which see). Owner also located Lodi No. 2 and Lodi No. 3 in 1938 to the south and possibly are relocations of the Lucky Jim (which see).

GOLD—Continued

Map No.	Name of claim, mine, or group	Location	Owner (Name, address)	Geology	Remarks and references
	Logwood	N½ sec. 21, T. 23 S., R. 5 E., M.D., astride Plaskett Ridge	Mrs. Sybella Luneta Thelan, Gorda Station, c/o Big Sur (1959)	Sheared and fractured Franciscan sandstone and slate striking N 15° E and dipping 45° W. Fractures filled with quartz veinlets which generally strike northwest and dip steeply northeast. Vuggy quartz on dump suggests possible mineralization	Relocated in 1957; adjoins Goodrich claim to the south. Developed by several older cuts and a shallow shaft. Some free-milling gold reportedly produced from an inclined shaft (caved) in the 1930's. No record of production.
51	Los Burros	Near W¼ cor. sec. 1, T. 24 S., R. 5 E., M.D.	Not determined		Unpublished records show that the Los Burros Mining and Development Co. produced 40 tons of ore carrying more than an ounce of gold per ton from the Los Burros mine in 1937. There is no other record for this mine, but it possibly is the same as the Los Burros mine indicated on Cape San Martin 15-minute quadrangle (1917 Ed.) of the U.S.G.S.
	Lucky Jim	Approx. W½ sec. 19, T. 23 S., R. 5 E., M.D.	J. C. Krenkle (1935)		Placer and quartz claim mentioned by Franke (35:463) as being located ½ mile from mouth of Plaskett Creek. Located in 1934; a relocation of the Home placer. No known production.
52	Lucky Jim placer	NW¼ sec. 1, T. 24 S., R. 5 E., M.D., west side Alder Creek	Not determined	Placer gravels(?) on Franciscan Formation	Unpatented claim of J. H. McNeil, who produced 6.7 ounces of gold and 2 ounces of silver from placer gravel in 1912. Claim relocated in part as the Lodi No. 2 or No. 3 in 1938.
53	Lucky Moe	S½ sec. 35, T. 23 S., R. 5 E., M.D., Los Burros district	H. Hilton, V. Swanson, and H. Stevens, Los Burros, c/o Big Sur (1959)	Franciscan sandstone and other rocks reportedly cut by two veins 4 to 6 inches thick striking N 80° E and dipping 45° S or steeper. Vein outcrops obliterated by surface cuts, but dump material consists of broken vein quartz and calcite intercalated with fault gouge containing finely-divided gold with pyrite and chalcopyrite	Unpatented lode claim; a relocation in part of the Condor group (which see). Developed by a 30-foot incline shaft driven north with a short drift to the east. Another short shaft lies immediately to the east. Records show that Elmo Soutlemoir produced a minor amount of gold in 1948. In 1953, E. A. Brewer, S. A. Gray and D. Page shipped 5 tons of ore to Selby for smelting and 4 ounces gold, 3 ounces silver, and 21 pounds copper were obtained. 25 tons of ore were reported on the dump in 1959 and minor production was recorded in 1963.
	Mammoth				See Mary S.
	Manchester (Blue Jay)	N¼ cor. sec. 2, T. 24 S., R. 5 E., M.D.	Not determined	One or two veins striking northeast and dipping southeast between a "slate hanging wall and serpentine footwall" (Preston 93:261).	The claim was active 1887–1893 and 1903; developed by 2 adits 60 and 100 feet long and a 27-foot shaft with a 30-foot drift. (Irelan 88:407; Preston 93:261) Relocated as the Mary S Extension (which see) in 1908 and possibly in part as the Blue Jay (which see) (Waring and Bradley 19:605). Probably some early production, but there is no record of this.
	Manzanita	SW¼ sec. 36, T. 23 S., R. 5 E., M.D.	Not determined		Mentioned and located by Preston (93:260). Reportedly developed by a 15-foot incline on a 2-foot vein of quartz. No record of production. Relocated as the Pine (which see) and other claims.
	Marion placer				See Plaskett placer.
	Mariposa	NE¼ sec. 2 or N½ sec. 1, T. 24 S., R. 5 E., M.D.	W. and R. Pugh, Rt. 1, Box 92, Soledad, and Donald Lazier (1960)	Quartz vein with free gold and arsenopyrite	Waring and Bradley (19:605) state the Mariposa mine consists of the Blue Jay No. 1 and 2 (which see), San Lucas, Protection and McKinley claims and is developed by a 60-foot inclined shaft and 30 feet of drift. No record of production. In 1960, W. Pugh stated the above group of claims was still owned by his family and that there was about 300 feet of adits on Blue Jay Nos. 1 and 2. He included the Mariposa claim, located in NW¼ sec 1(?), in the group.
	Mars				See West Extension No. 1.
	Mary S (Mammoth)	SE¼ sec. 35, T. 23 S., R. 5 E., M.D.	Buclimo Mining Co., 1361 7th Ave., San Francisco (1959)		A patented lode claim used as a mill site for the Buclimo mine (which see). No known production. A relocation of the Mammoth claim mentioned by Preston (93:260).
	Mary S Extension	N¼ corner sec. 2, T. 24 S., R., 5 E., M.D.	Buclimo Mining Co., 1361 7th Ave., San Francisco (1959)		Essentially a relocation of the Manchester (which see). Now a patented claim of the Buclimo (which see). No record of production.
54	Melville (M.M. mine)	W½ sec. 35, T. 23 S., R. 5 E., M.D., along Willow Creek road	Melville Consolidated Mines, including G. W. and K. P. Melville, c/o Big Sur, and others of the Melville family, (1959)	Franciscan Formation, mainly sandstone, cut by small veins of quartz in shear zones and a large, nonmineralized vein of bluish quartz, which generally strike west to northwest and dip steeply north	Consists of 12–14 lode and placer claims and 3 mill sites developed by at least 9 adits, 2 shafts, several short drifts and several surface cuts and pits. Some of the workings are inaccessible, but are estimated to total over 1000 feet in length. The mine group has been in litigation since 1933 and there has been little development in recent years. There is no record of production, but some gold may have been obtained prior to 1900. (Irelan 88:408; Hill 23:328; Laizure 25:40; Franke 35:463–464).

GOLD—Continued

Map No.	Name of claim, mine, or group	Location	Owner (Name, address)	Geology	Remarks and references
	Miller claim	Not determined	Not determined		Unpublished records show that G. A. Miller produced a minor amount of gold and silver from a placer claim in 1932. The claim location is not known, but it may have been located in the Los Burros district along the north fork of Willow Creek near the Yellow Quartz claim, also owned by Miller at that time.
55	Miner's Gulch area	Sec. 33, T. 17 S., R. 7 E., M.D., 3 to 4 miles north of Metz	Not determined	Minor gravel deposits	Gold has been reported from the stream gravel in Miner's Gulch, a tributary to Chalone Creek. A number of small prospects were opened along the gulch, mostly in sec. 33, but nothing important was found (Andrews 36:33, map). No record of production.
	M.M. mine				See Melville.
56	New York	NE¼ sec. 1, T. 24 S., R. 5 E., M.D.	John Lazier and Ade Harboldt, Pacific Grove (1959)		Includes the New York, Triangle and California claims, and possibly the Good Deal. (Hill 23:327; Laizure 25:40; Franke 35:464; Goodwin 57:571; herein.)
	None Such	Not determined	Not determined		Unpublished records show that S. O. Pugh produced 1.74 ounces of gold from 3 tons of free milling ore of the None Such claim in 1909. According to W. W. Pugh, son of S. O. Pugh, this claim was located on the South Fork Willow Creek and was productive of placer gold, being worked out and abandoned around 1915 (personal communication, 1960).
	North Extension				See East Extension No. 1.
	Nugget Gulch				See Gillis claims.
	Ocean View				See Plaskett.
	Old Man of the Mountains	Approx. SW¼ sec. 35, T. 23 S., R. 5 E., M.D.	Not determined	Stringers of vein quartz in Franciscan rocks	Mentioned by Irelan (88:408) as lying west of the Ophir and being developed by 3 adits totalling 185 feet. Some placer gold reportedly produced after heavy rains in 1889. Probably relocated several times and now is part of the Melville (which see).
	Ophir	SW¼ sec. 35, T. 23 S., R. 5 E., M.D.	Not determined	Franciscan rocks cut by stringers of quartz mixed with slate	Mentioned by Irelan (88:408) as lying west of the Grand Pacific. It was worked by an adit and inclined shaft, each being 30 feet long. Probably now part of the Melville (which see).
	Olivene				See Bauman claims.
	Ora F No. 2				See Grizzly (also see Buclimo).
	Oregon	SE¼ sec. 35, T. 23 S., R. 5 E., M.D.	Mrs. Margaret Krenkle(?), Jolon (1959)		The Oregon mine reportedly consists of the Oregon and Cool Springs claims, and is developed by a 128-foot adit, 80 feet of drifts and a 50-foot raise (Waring and Bradley 19:605: Laizure 25:41; Franke 35:464). The above workings are believed to apply only to the Cool Springs (which see) in sec. 1. According to Doreen Krenkle, the Oregon claim is not contiguous with the Cool Springs and lies south of the Mary S claim of the Buclimo. The Oregon claim is said to be developed by a 200-foot adit, driven north, and intersected by an incline shaft at 100 feet. Some oxidized ore was reportedly produced from the shaft and milled in an arrastra about 1900. However, there is no record of production. The Oregon probably is a relocation of the Pine Cone mentioned by Preston (93:260, map).
	Oro Grande				See Plaskett placer.
	Pine Cone				See Oregon.
57	Plaskett (Howard, Ocean View)	NE¼ sec. 19 and NW¼ sec. 20, T. 23 S., R. 5 E., M.D.	Jessie E. Plaskett, 123 Winham St., Salinas, and Violet M. Lowe, Gorda Station, c/o Big Sur; also Allvec Mining Co., Rm. 615, 610 S. Broadway, Los Angeles (1960)		Consists of 4 patented lode claims (Ocean View, Lilac, Blackberry, Hollyberry), 3 of which were productive. (Davis 12:697; Waring and Bradley 19:603, 605; Hill 23:326, 329; Laizure 25:41; Franke 35:464; herein.)
58	Plaskett placer	Approx. N¼ corner sec. 27, T. 23 S., R. 5 E., on North Fork Willow Creek	Not determined		Productive placer deposit consisting of the Marion and Oro Grande claims. Probably relocated in part as the Humbug (which see). (Davis 12:697; Waring and Bradley 19:603; Hill 23:326; herein.)
	Providence				See Bauman claims.
	Queen	SE¼ sec. 35, T. 23 S., R. 5 E., M.D.		Northeast striking, westerly dipping veins in "slate".	Mentioned by Preston (93:260, 261). Developed by 3 short adits. (Waring and Bradley 19:605). It is now the Pine claim of the Buclimo (which see).

GOLD—Continued

Map No.	Name of claim, mine, or group	Location	Owner (Name, address)	Geology	Remarks and references
59	Queen Hattie	SW¼ sec. 21, T. 23 S., R. 5 E., M.D.	Marty Hess, Los Burros and A. C. Wolk, Skagway, Alaska (1962)	Franciscan sandstone and slate cut by veinlets of quartz associated with fault gouge.	Unpatented claim located south of the Goodrich. According to the present owner it was discovered in the 1890's by John Bushnell, who obtained gold from an inclined shaft about 1900. The ore was reported to occur in a north-trending shear zone. Other workings consist of an inaccessible, short adit driven northwest and an adit driven to the east and partly caved. The latter was being cleaned out in 1960. There is no record of production.
	Ralston Mining Co.				See Spruce Creek placer.
	Rocky Bar	Sec. 23, T. 23 S., R. 5 E., M.D.	Nellie Binns (1937)	Placer gravel, probably on North Fork of Willow Creek.	According to unpublished records 1.17 ounces of gold were produced from this claim by P. J. Smith in 1932. The gold was obtained from 40 cubic yards of gravel by small scale hand methods.
60	Ruby placer	Approx. NW¼ sec. 22, T. 22 S., R. 7 E., M.D., 3 miles northwest of Jolon.	Hunter-Liggett Military Reservation or Milpitas Rancho	Quaternary stream gravel	In 1914, an attempt to recover gold from gravel in Old Man Canyon was made by the Hess brothers, who dammed the canyon and dredged the ponds formed from flood waters. By means of a trommel screen and riffles, as much as 50 cents worth of gold per cubic yard was recovered, but the operation was unsuccessful (Waring and Bradley 19:606; Laizure 25:41; Weidman 58:202). No record of production. Also see Jolon area under introduction to Gold section (herein).
	San Anton	Not determined	Not determined	Stream gravels (?)	Unpublished records show a little more than one ounce of placer gold was produced in 1935 by Lee Aston who employed small scale hand methods.
	Scorpion	Not determined	Not determined		Prospect developed by 30 feet of workings (Irelan 88:409, 410). No known production.
	South Extension				See West Extension No. 1.
61	Spruce Creek placer	Mainly sec. 3 and 4, T. 24 S., R. 5 E., M.D.	Multiple		More than 1,000 ounces of placer gold have been produced along South Fork Willow Creek (previously known as "Spruce" Creek) by Ralston Mining Co. and other individuals. (Herein).
	Stonewall	Approx. sec. 34, T. 23 S., R. 5 E., M.D.	Not determined	"2-foot vein of quartz mixed with slaty matter, dipping to the northeast at angle of 45 degrees." Ore shows galena sparsely distributed in vein (Irelan 88:409).	Claim located 1300 feet west of Melville mine (Irelan 88:409). No known development.
	Toro Quartz	SE¼ sec. 33, T. 23 S., R. 5 E., M.D.	James Brown (?), Soquel (1959)	Franciscan rocks	Franke (35:464) mentions that J. W. Mathers developed this claim by a 25-foot shaft and 2 tunnels, one of which was 60 feet long. The claim was reportedly owned by a Mr. Hulen and, later, James Brown. When visited in 1959, numerous adits and prospect pits were seen along Willow Creek road and the private road south to South Fork Willow Creek. The adits were more or less inaccessible and the claim was idle. No known production.
	West Extension No. 1 (Mars, South Extension)	S¼ cor. sec. 35, T. 23 S., R. 5 E., M.D.	Buclimo Mining Co., 1361 7th St., San Francisco (1959)		Lode claim originally located as the Mars claim in 1887. In 1888, the workings consisted of a 75-foot adit driven northerly to intersect the Last Chance (Buclimo) vein (Irelan 88:407). The Mars claim was relocated about 1890 as the South Extension and in 1908 as the West Extension No. 1 of the Buclimo (which see). The patent plat of the Buclimo shows a 700-foot adit extending north from this claim to the adjacent Charleston claim. This may be a tunnel driven in 1889 to drain the Charleston (which see), but never completed.
	Yellow Quartz				See Bushnell.
	(Unnamed)	Sec. 26 or 27(?), T. 18 S., R. 5 E., M.D.	Not determined		Gold prospect on the north branch of Little Sur River mentioned by Fiedler (44:247). Adits, now inaccessible, were developed in non-mineralized, quartz-rich pegmatite. No record of production.

LEAD

	Alisal Ranch				See under Silver.
	New York				See under Gold.
	Stonewall				See under Gold.

LIMESTONE & DOLOMITE

Map No.	Name of claim, mine, or group	Location	Owner (Name, address)	Geology	Remarks and references
	Alisal Ranch........				See Spreckels.
	Bardin prospects.....	Sec. 3, T. 15 S., R. 4 E., M.D., 5½ miles north of Chualar.	Walter Bardin Ranch (1960)	Crystalline limestone, locally dolomitic and silicated.	Several prospect pits developed many years ago by Spreckels Sugar Co. for possible use in sugar refining. Limestone bodies appear to be too small and impure for commercial development.
62	Bardin Ranch........	SE¼ sec. 33 and SW¼ sec. 34, T. 13 S. and NW¼ sec. 3, T. 14 S., R. 4 E., M.D., one mile west of Fremont Peak.	Bardin Ranch (1959)......		Three deposits of potentially commercial, crystalline limestone. (Bowen and Gray 59:28, Pl. 1; herein; under Fremont Peak district).
63	Bethlehem Steel Co...	Near SE cor. sec. 35, T. 13 S., R. 4 E., M.D., 6 miles northeast of Salinas	Probably Kaiser Aluminum and Chemical Corp., 300 Lakeside Drive, Oakland (1960)	Crystalline dolomite; part of the Natividad deposit (which see).	Bethlehem Steel Co. (and its predecessor, Pacific Coast Steel Co.) operated a dolomite quarry just north of the Natividad quarries from 1926 to 1944 to supply dolomite to line the bottoms of open-hearth steel furnaces. A nearby quarry (not located) is reported to have been worked to supply limestone for use in beet sugar refining prior to 1910. (Boalich 21:156; Allen 46:67–68; Logan 47:257–258; herein, under Natividad deposit).
64	Bixby Creek.........	N½ sec. 16, T. 18 S., R. 1 E., M.D., 12 miles south of Carmel.	Not determined.........	Crystalline limestone...........	Deposit operated 1904–1910 by Monterey Lime Co. as source of limestone for lime. (Aubury 06:72–73; Logan 47:258, 259; herein, under Coast Ridge district).
65	Blue Rock Mt........	SW¼ sec. 25 and SE¼ sec. 26, T. 14 S., R. 4 E., M.D., 9 miles east of Salinas.	Barnes Ranch (1959)......		Undeveloped deposit of crystalline limestone having commercial potential. (Bowen and Gray 59:37; herein, under Hartnell district).
	Chalone Creek......	Approx. SE¼ T. 17 S., R. 7 E., M.D., 6 miles east of Metz.	Not determined.........		Undeveloped limestone deposit. (Logan 47:259).
66	East Gabilan.........	SW¼ sec. 36, T. 13 S., R. 4 E., M.D., 1 mile east of Fremont Peak.	Reeves Ranch, leased to Ideal Cement Co. (1959)		Partly developed; substantial reserves of good quality limestone. (Bowen and Gray 59:28, 30, Pl. 1; herein, under Fremont Peak District).
67	Fremont Peak........	S½ sec. 35, T. 13 S., R. 4 E., M.D., ¼ mile south of Fremont Peak.	Reeves and Bardin Ranches (1959)		Moderately small deposit of good quality limestone. (Bowen and Gray 59:31, Pl. 1; herein, under Fremont Peak District).
	Gabilan Peak (Bardin)	S½ secs. 34 and 35, T. 13 S and N½ secs. 2 and 3, T. 14 S., R. 4 E., M.D.	Bardin Ranch and State of California (1959)		Logan (47:259) mentioned siliceous limestone deposits south and west of Fremont Peak, which are described more specifically as the Bardin Ranch and Fremont Peak deposits (which see).
	Jamesburg..........				See Lambert Ranch.
	Jolon..............	Not determined.............	Not determined.........		A "shell deposit" a few miles south of Jolon supplied material for a lime kiln operated prior to 1893. (Preston 93:260; Logan 47:259).
68	Junipero Serra.......	Sec. 6, T. 21 S., R. 5 E., M.D., 19 miles west of King City.	Sparks, Pearson and Bert Talcott, Salinas (1958)		An undeveloped body of crystalline limestone in the Santa Lucia Range. Also includes the Watkins prospect in sec. 36, T. 20 S., R. 4 E. (Herein, under other deposits in Santa Lucia Range).
	Kellogg Ranch......	Not determined.............	Not determined.........		Limestone quarry located 16 miles southeast of Salinas on property owned by Martha Bardin, Hazel Hurt and Ethel Tholcke; operated prior to 1910 by Spreckels Sugar Co. for limestone used in beet sugar refining (Laizure 25:43; Logan 47:258). Possibly part of the Quail Creek deposit (which see).
69	Lambert Ranch (Jamesburg)	SW¼ sec. 17, SE¼ sec. 18, NW¼ sec. 20, T. 18 S., R. 4 E., M.D., 1½ miles southeast of Jamesburg.	Lambert Ranch, Jamesburg (1954)		Three small limestone lenses developed many years ago by 2 small quarries. (Herein, under Santa Lucia Range).
70	Limekiln Creek (near Lucia)	Sec. 15, T. 22 S., R. 4 E., M.D., 1 mile east of Lucia.	Not determined.........		Large body of limestone and dolomitic limestone developed at its northwest end by small hillside quarries. Used as a source for lime which was burned in nearby kilns owned by Rockland Lime and Lumber Co. (Irelan 88:410–411; Preston 93:260; Crawford 94:392–393; Crawford 96:629; Aubury 06:72; Reiche 40:163; Logan 47:259; Mohler 57:7; herein, under Coast Ridge District).
71	Limekiln Creek (near Chualar)	E½ sec. 28, T. 16 S., R. 4 E., M.D., 4 miles south of Chualar.	Stolich Ranch (?), Chualar.		Tiny pod of crystalline limestone used to make lime many years ago. (Herein, under Santa Lucia Range).
72	Los Vergeles........	Near W¼ cor. sec. 18, T. 13 S., R. 4 E., M.D., 4 miles southwest of San Juan Bautista.	Los Vergeles Ranch.......		Small production of limestone developed prior to 1923 from a quarry located along San Juan Grade road. (Aubury 06:73; Laizure 25:43; Allen 46:72; Logan 47:259, herein under Los Vergeles District).
73	Marble Peak	Sec. 22, T. 20 S., R. 3 E., M.D., 18 miles southeast of Point Sur.	Not determined.........		Logan (47:259) mentions several small deposits flanking Marble Peak on west and south. These deposits, as well as some of the limestone lenses extending 9 miles to the northwest, were briefly examined by the author in 1960 and appear to be too small and impure to be of economic value. Additional limestone bodies extend several miles

LIMESTONE & DOLOMITE—Continued

Map No.	Name of claim, mine, or group	Location	Owner (Name, address)	Geology	Remarks and references
	Marble Peak—Cont.				southeast, but these were not visited. They have been mapped by Reiche (40:map) and appear to be small for the most part. However, a limestone body in secs. 21 and 22 T. 21 S., R. 4 E. is more than a mile long and ¼-mile wide and may be worth investigating at some future time. It is accessible only by Coast Ridge or Arroyo Seco trails.
74	Natividad	Secs. 1 and 2, T. 14 S., and secs. 35 and 36, T. 13 S., R. 3 E., M.D., 6 miles northeast of Salinas.	Kaiser Aluminum and Chemical Corp., 300 Lakeside Drive, Oakland (1960)	Large pendant of crystalline dolomite in granitic rocks.	Large, active dolomite quarry. (Allen 46:69, map, Logan 47:256–257, 197; Utley 52:94–96; Lenhart 53:89–93, Utley 59:84–85; Bowen and Gray 59:22, 25; herein under Natividad District).
75	Nelson Creek	Sec. 22, 23 and 26, T. 22 S., R. 13 E., M.D., 9 miles northwest of Parkfield.	A. M. and M. R. Claassen, San Miguel (1964)		Large bodies of limestone are reported to occur along Nelson Creek. They are undeveloped. (Crawford 94:392; Crawford 96:629; Logan 47:259; herein, under San Andreas fault zone).
	Pacific Carrara Marble Co.	Not determined	Not determined		A company by this name was organized prior to 1880 to work a deposit of white marble near Carmel. No record of production. (Hanks 84:110; Logan 47:260).
76	Patriquin	Sec. 6, T. 23 S., R. 14 E., M.D., 5 miles northwest of Parkfield.	Not determined		Deposit of white marble; undeveloped. (Waring and Bradley 19:607; Logan 47:260; herein, under San Andreas fault zone).
77	Pico Blanco	Secs. 25 and 36, T. 18 S., and secs. 1, 2, 11 and 12, T. 19 S., R. 1 E., M.D., 5 miles east of Point Sur.	Granite Rock Co., P.O. Box 151, Watsonville (1963)		Immense deposit of crystalline limestone of good quality and strong economic potential. (Logan 47: 260; herein, under Coast Ridge District).
78	Porter	W½ sec. 7, T. 14 S., R. 4 E., M.D., 5 miles northeast of Salinas.	James Porter, 701 Old Stage Road, Salinas (1959)		Undeveloped deposit of crystalline dolomite similar to the Natividad deposit nearby. (Bowen and Gray 59:28; herein, under Natividad District).
79	Quail Creek	N½ sec. 7, T. 15 S., R. 5 E., M.D., 6 miles northeast of Chualar.	Hazel Hurt, Salinas, leased to Barnes Construction Co., 2556 Mission St., San Marino (1960)		An elongate mass of limestone and dolomite developed by small quarries in the early 1900's and a large quarry in 1959. (Bowen and Gray 59:37; herein, under Quail Creek-Mt. Olds District).
80	Sierra (Serra) Hill-Little Sur	S½ T. 18 S., R. 1 E., M.D., 3 miles north of Point Sur.	Not determined		Several long, sinuous bodies of crystalline limestone mapped by Trask (26:map). Not developed. (Herein).
81	Spreckels	NE¼ sec. 20 and NE¼ sec. 30, T. 14 S., R. 4 E., M.D.	Sillacci Ranch (1959)	Small pendants of crystalline limestone cut by dikes of weathered granitic rock.	During the early 1900's, Spreckels Sugar Co. operated several quarries on the Alisal and Gabilan Ranchos for use in refining beet sugar and as crushed rock and rubble masonry. (Aubury 06:73; Laizure 25:42–43; Logan 47:258; herein under Hartnell District). Also see Sillacci—lower quarry under Stone, crushed.
82	Sugarloaf	Secs. 25 and 36, T. 13 S., R. 3 E., M.D., 7 miles northeast of Salinas.	Not determined		Two broad belts of dolomite-calcite rock of generally impure nature and little development. The belt ½ mile south of Sugarloaf was reportedly developed as a source of limestone for lime at one time. (Allen 46:72; Bowen and Gray 59:28; herein under Natividad District).
83	Tassajara	NE¼ sec. 29, T. 19 S., R. 4 E., M.D.	Not determined	White crystalline limestone associated with schist and cut by dikes of granitic or pegmatitic rock.	Lime from a limestone deposit 3 miles by road north of Tassajara Hot Springs was used as mortar in construction of the hotel at the hot springs (Fiedler 44: 203, 248).
	Watkins prospect				See Junipero Serra.
	Webb and Mingus	Sec. 28, T. 24 S., R. 16 E., M.D., 12 miles southeast of Parkfield.	Not determined	Deposit doubtful as area underlain by Tertiary and Upper Cretaceous sedimentary rocks and some serpentine	Deposit of dolomite reported on 160 acres of land owned by E. A. Webb and S. M. Mingus prior to 1925 (Laizure 25:36). No known development.
84	Westphal Ranch	Sec. 10 and 11, T. 15 S., R. 5 E., M.D., 8 miles northeast of Chualar.	Herald Ranch, c/o Herb G. Meyers, 145 Auburn St., Salinas (1959)		Undeveloped lenses of limestone and dolomite. May be too small and impure to be commercial. (Bowen and Gray 59:38–39; herein under Quail Creek-Mt. Olds District).

MAGNESITE & MAGNESIUM COMPOUNDS

	Bedell	Sec. 28, T. 23 S., R. 15 E., M.D., 4 miles east of Parkfield	Probably Floyd Taylor, Parkfield (1960)	Small masses of magnesite in serpentine reported	L. E. Bedell developed shallow pits or trench prior to 1919. No known production. (Waring and Bradley 19:607; Bradley 25:53.)
85	Kaiser Aluminum and Chemical Corp. (Moss Landing magnesia plant).	Sec. 18, T. 13 S., R. 2 E., M.D., at Moss Landing	Kaiser Aluminum and Chemical Corp., 300 Lakeside Dr., Oakland (1960)		Large integrated plant processing seawater to obtain magnesium hydroxide, which is processed into a variety of magnesias. (Byrns 50:152–155, 200–203; Ceramic News 57:48–49; Ver Planck 57: 316, 318; Forbath 58:112–115; Utley 59:84–85; herein.)
	Kings	Sec. 26, T. 23 S., R. 15 E., M.D., 6 miles east of Parkfield	Probably Hancock Ranch, Parkfield (1960)	Small masses of magnesite in serpentine reported	Developed by test pits many years ago. No record of production. (Bradley 25:53.)

MAGNESITE AND MAGNESIUM COMPOUNDS—Continued

Map No.	Name of claim, mine, or group	Location	Owner (Name, address)	Geology	Remarks and references
	Nevins	Sec. 29, T. 23 S., R. 15 E., M.D., 3 miles east of Parkfield	Not determined	Small masses of magnesite in serpentine reported. Analysis shows magnesite to be 95.6% magnesium carbonate	Developed by small prospect pits and cuts (Laizure 25:43–44). It is reported that a truck load of ore was shipped to Los Angeles for testing about the time of World War I.

MANGANESE

Map No.	Name of claim, mine, or group	Location	Owner (Name, address)	Geology	Remarks and references
86	Evans prospect	SW¼ sec. 24, T. 24 S., R. 6 E., M.D.	W. J. & J. C. Evans, San Simeon (1918)		Undeveloped deposit. (Trask 50:153–154; herein.)
87	Hidden Valley Ranch (Wayland Ranch)	E½ sec. 9, T. 22 S., R. 13 E., M.D., 19 miles east of San Ardo	Hope Bagby, Hidden Valley Ranch, San Miguel (1960)		Minor prospecting; no production. (Trask 50:154; herein.)
	Ross Ranch				See Young Ranch.
	Schmidt prospect	SW¼ sec. 9, T. 18 S., R. 7 E., M.D.	August Schmidt, Star Rt. 3, Soledad, and a Mr. Ortner (1959)	Zones of manganese oxide as much as 30 feet wide and 500 feet long reported by owners. Said to run 12–30% manganese. (This occurrence is questionable as the area is underlain by granitic and metamorphic rocks in which manganese oxide deposits are not known.)	No development known.
	Wayland Ranch				See Hidden Valley Ranch.
88	Young Ranch (Ross Ranch)	SE¼ sec. 32, T. 24 S., R. 6 E., M.D., near southwest corner of county	Monte Young, P.O. Box 43, San Simeon (1959)		Minor development and production. (Bradley 18:50–51; Trask 50:154; herein.)

MERCURY

Map No.	Name of claim, mine, or group	Location	Owner (Name, address)	Geology	Remarks and references
89	Botts	SE¼ sec. 7, T. 24 S., R. 8 E., M.D., 4 miles northwest of Bryson	Victor Botts, Paso Robles (1941)		Some development prior to 1940. (Eckel, et al. 41:548, 579–580; herein.)
	Cholame-Parkfield				See Patriquin.
	Dutro (or Dutra)				See Old Murry.
	Franciscan				See Patriquin.
90	G.W.D.	E½ sec. 2, T. 23 S., R. 14 E., M.D., 4 miles north of Parkfield	Not determined	Landslide mass composed of silica-carbonate rock and serpentine derived from the area of the Patriquin glory hole 1500 feet to the north. Ore bodies are shallow, as much as 50 feet long, and consist of secondary cinnabar in soil and crushed rock. Primary cinnabar in silica-carbonate rubble is too scant to be considered ore where not enriched (Bailey 42:162–163).	Name derived from developers Gillette, Washburn, and Day (lessees) of Coalinga. Developed by 2 small open cuts and several short adits which explore secondary ore zones. Small production obtained, using a small retort, 1936–37 and 1939–41. As there has been no further production record, it is assumed the mine has been idle since about 1941. (Ransome and Kellogg 39:403; Bailey 42:147. 157, 163.)
91	Gillette mine (Patriquin-Gillette)	W½ sec. 1, T. 23 S., R. 14 E., M.D., 4 miles north of Parkfield	Henry Ludeke, Jr., Parkfield (1942)	Reported to be a southeast extension of the Patriquin ore zone, which consists of veinlets and encrustations of cinnabar in silica-carbonate rock and sheared serpentine (see Bailey 42:160–162 for description). Vein varies in width from 6 inches to 3 feet (Bradley 18:73).	Developed in 1917 by the Patriquin brothers who drove 6 or 7 short adits, totalling 150 feet. The ore was reduced in a D-type retort, resulting in a few flasks of mercury in 1917. N. Gillette leased the property at a later date and attained small, intermittent production 1937–40. There has been no production since then and the mine is idle. (Bradley 18:73, Laizure 25:51; Ransome and Kellogg 39:402.)
	Gillette prospect	Near south boundary sec. 2 (?), T. 23 S., R. 14 E., M.D.	Henry Ludeke, Jr., Parkfield (1942)	Cinnabar veinlets in silica-carbonate rock, which is similar to that of G.W.D. and Poppy mines, and probably part of the same landslide	Prospect mentioned by Bailey (42:157, 163). No known production, but minor development by N. Gillette.
	Monte Cristo group	Not determined	Not determined		Several quicksilver claims located near Gorda by W. D. Cruikshank prior to 1918. Developed by assessment work only. No known production (Bradley 18:73; Laizure 25:50; Ransome and Kellogg 39:476).
92	Moore Ranch	SW¼ sec. 31, T. 18 S., R. 5 E., M.D.	Wes Moore, Greenfield (1936)	Cinnabar on fracture planes in sandstone and along calcite vein in Vaqueros Formation near granodiorite contact	Prospect discovered about 1885. Reported to be developed at different times by several prospect shafts and adits prior to 1936. Located at elevation of 2,000 feet; no record of production (1936, unpublished data Div. Mines and Geology).

MERCURY—Continued

Map No.	Name of claim, mine, or group	Location	Owner (Name, address)	Geology	Remarks and references
	Murray				See Old Murry.
93	Old Murry (Murray, Dutro, Dutra)	SE¼ sec. 28, T. 24 S., R. 6 E., M.D., near southwest corner of county	Monte Young, P.O. Box 43, San Simeon (1959)		Small production, beginning 1894 or earlier. (Crawford 94:362, Bradley 18:73, Forstner 03:124, Waring and Bradley 19:613, Laizure 25:50, Ransome and Kellogg 39:476, Eckel 41:577–578, herein.)
	Parkfield				See Patriquin.
94	Patriquin (Pitts, Cholame-Parkfield, Parkfield, Franciscan)	NE¼ sec. 2, T. 23 S., R. 14 E., M.D., 4 miles north of Parkfield	Fred Harker, 421 Piedmont Ave., Glendale (1960)		The largest mercury mine in the county, yielding over 1,000 flasks of mercury. (Forstner 03:123–124, Bradley 18:73–75, Waring and Bradley 19:613–614, Laizure 25:51–53, Franke 35:462, Ransome and Kellogg 39:403–404, Bailey 42:147, 157, 160–162, herein.)
	Patriquin-Gillette				See Gillette mine.
	Pitts				See Patriquin.
95	Poppy	E½ sec. 2, T. 23 S., R. 14 E., M.D., 4 miles north of Parkfield	Not determined	Geology and ore are identical to the adjacent G.W.D. mine (which see), being situated on the same landslide containing cinnabar-bearing silica-carbonate rock	N. Gillette and T. E. Washburn of Coalinga developed small production in 1932 and 1933 from small pits and short adits. No recent development. (Ransome and Kellogg 39:404, Bailey 42:147, 157, 163.)
96	Rattlesnake	Near N¼ sec. 30, T. 23 S., R. 16 E., M. D., 8½ miles east of Parkfield	Probably R. D. & M. Freeman, Parkfield (1960)	Small silica-carbonate rock mass in serpentine just above a thrust fault. No ore visible in silica-carbonate outcrops, but soil above is said to pan cinnabar	Situated just south of ridge crest. Developed prior to 1942 by an adit driven 60 feet to north and caved at 30 feet (Bailey 42:157, 167). About 1,200 feet northeast, a large cut, now partly collapsed, has been made in sheared serpentine immediately east of the silica-carbonate body. A 4-pipe brick retort testifies to earlier production. No recent activity.
97	Sommer's prospect	NW¼ sec. 2, T. 23 S., R. 14 E., M.D., 4 miles north of Parkfield	L. J. Sommer (1942)	Thin northwest-trending rib of silica-carbonate rock at base of serpentine mass that has been thrust over Franciscan sandstone. Cinnabar occurs only as thin films on fresh serpentine	Several short adits explore silica-carbonate rock, serpentine and sandstone, but none are known to have intersected the fault zone (Bailey 42:157, 163–164). No record of production and no recent activity.
	Table Mountain				See White.
98	White (Table Mountain)	NE¼ sec. 30, T. 23 S., R. 16 E., M.D., 9 miles east of Parkfield	Not determined	Thin body of brecciated silica-carbonate rock and serpentine developed along a fault zone of east-west strike and north dip. Cinnabar occurs as thin coatings in fractures of silica-carbonate rock and sheared serpentine. The best ore was estimated to run 10 pounds of mercury per ton. (See Bailey 42:166–167 for a little more detail.)	Situated at the county boundary and developed as early as 1916 when 3 flasks of mercury were recovered in a 12-pipe retort. The mine was reopened in 1941 and possibly a little more production obtained, but there is no record of this. The workings consist of 3 short adits, driven to the northeast, and several small drifts and stopes. No recent activity. (Forstner 03:124–125, Bradley 18:75, Waring and Bradley 19:614, Ransome and Kellogg 39:404, Bailey 42:147, 157, 166–167.)
	(Unnamed)	Sec. 27 or 28, T. 17 S., R. 2 E., M.D., along San Clemente Creek(?)	Not determined	Silica-carbonate rock within Blue Rock fault zone	Fiedler (44:248) mentions an old mercury prospect developed by several shafts prior to 1937. No known production.
	(Unnamed)	Sec. 4, T. 18 S., R. 4 E., M.D., 3 miles northeast of Jamesburg	Not determined	Andesite lava in "Vaqueros-Tembler" formation. No mineralization noted at surface	"An old drift, now almost completely slumped, on Red Rock Hill north of Madrona Canyon marks what may have been a mercury prospect" (Fiedler 44:248). No record of production.

MINERAL WATER

Map No.	Name of claim, mine, or group	Location	Owner (Name, address)	Geology	Remarks and references
	Bane's Soda Springs	Sec. 25(?), T. 24 S., R. 5 E., M.D.	Not determined	Franciscan Formation	Carbonated water issuing from a bluff overlooking the ocean has built a small, but notable terrace of iron-stained calcium carbonate. No known development. (Crawford 94:340, Waring 15:215, Laizure 25:45.)
	Big Sur Hot Springs				See Slate's.
99	Dolan's Hot Springs	Sec. 24, T. 21 S., R. 3 E., M.D., 5 miles northwest of Lucia	Not determined		A warm and mildly sulfurous spring along Big Creek 1½ miles from the ocean. Not developed and seldom visited. (Crawford 94:340, Waring 15:57, Waring and Bradley 19:607, Laizure 25:45.)
	Helms Soda Springs	About 3 miles east of Bane's Soda Springs	Not determined		Strongly carbonated water issues in a slight rate of flow. No known development. (Crawford 94:340, Waring 15:216, Laizure 25:45.)
100	Little Sur Hot Springs	Approx. south line of sec. 26, T. 18 S., R. 1 E., M.D., 6 miles northwest of Big Sur	Not determined	Mildly sulfurous springs in fractured granitic rock	Several thermal springs with a maximum temperature of 114° F. occur along the stream and banks of the north fork of the Little Sur River. During the 1890's, the spring water was piped downstream to a grove of redwood trees where it was contemplated that a hotel and bath house would be built. However,

MINERAL WATER—Continued

Map No.	Name of claim, mine, or group	Location	Owner (Name, address)	Geology	Remarks and references
	Little Sur Hot Springs —Cont.				the pipeline was washed out during a subsequent flood and no further development is known. (Irelan 88:411; Waring 15:57; Waring and Bradley 19:610; Laizure 25:45.)
	Monterey Mineral Well (O'Conner Mineral Spring)	Not determined	Not determined	A partial analysis indicates the water is a chloride type and contains .585 grams per 100 cc (approx. 6,000 p.p.m.) of total solids	A 50-foot well originally dug by O'Conner and later (1923) sold to O. P. Colburn of Monterey. The water was used hot or cold for bathing and was bottled and sold from 1914 to 1924. (Laizure 25:44.)
	O'Conner Mineral Spring				See Monterey Mineral Well.
101	Paraiso Hot Springs	SW¼ sec. 30, T. 18 S., R. 6 E., M.D., 6 miles west of Greenfield	O. T. Barrett, Paraiso Springs, Soledad (1961)	Several hot and cold springs issue from conglomeratic sandstone of the Berry Formation of Oligocene age lying on Santa Lucia granodiorite. The waters probably are brought up along fractures associate with nearby faults.	The springs were discovered by the mission fathers about 1790. It was developed as a resort around 1890 and has been operated ever since. Moderate variations in chemical content of the waters, which are rather high in total solids, have given rise to such local names as Hot Soda Springs, Hot Sulfur Springs, Iron Spring and Arsenic Spring. The spring waters are (were) used for bathing and drinking and some mineral water was sold for drinking purposes for many years prior to 1921. (Anderson 92:217–220; Crawford 94:34; 96:513–514; Waring 15:60–62; Waring and Bradley 19:607–609; Laizure 25:45–47; Fitch 27:259–260.)
102	Slate's Hot Springs (Big Sur Hot Springs)	NE¼ sec. 9, T. 21 S., R. 3 E., M.D., 12 miles southeast of Big Sur	Hot Springs Lodge, Coast Highway c/o Big Sur (1961)	A series of springs issue from a bluff bordering the ocean and at Hot Creek to the east. The geology consists of shale (slate?) and sandstone of Cretaceous age locally overlain by Quaternary terrace gravels. The springs emanate at or near the base of the gravels.	Reportedly discovered by Thomas B. Slate, who settled there in 1868. The springs range from 110° to 121° F. at the bluffs and 98° F. at Hot Creek (Waring 15:56–57). A private bath house was built prior to 1908 and later a resort was constructed. (Irelan 88:411; Crawford 94:341; Waring and Bradley 19:609–610; Laizure 25:47.)
103	Tassajara Hot Springs	SE¼ sec. 32, T. 19 S., R. 4 E., M.D., 10 miles south of Jamesburg	Tassajara Springs Resort (1961)	About 17 thermal springs issue from Sur Series metamorphic rocks along the bed and bank of Tassajara Creek. Temperatures range from about 100° to 140° F. and the largest springs flow as much as 7–8 gallons per minute. The spring waters contain about 360 p.p.m. solids of which sodium, sulfate and silica predominate. In the north bank above the creek, 2 cool springs issue water of different composition	The springs were known and used by Indians and early settlers. Developed by a stone hotel prior to 1896. It is reported that the older structures have been destroyed and newer facilities built. The water has been used for bathing and drinking purposes and some was bottled for sale at the turn of the century. The hot springs are reached by an improved, winding road from Jamesburg and are still operated as a resort. (Irelan 88:411; Crawford 94:341; 96:514; Waring 15:57–60; Waring and Bradley 19:610–613; Laizure 25:47–50.)
	(Unnamed)	12 miles north-northwest of Jolon	Not determined		Cool sulfur spring reported on Mission Creek on Milpitas grant. Used to a slight extent for drinking purposes. No known development. (Waring 15:276; Laizure 25:47.)

MOLYBDENUM

	Westcott Ranch	Approx. sec. 26 or 27, T. 17 S., R., 7 E., M.D., 8 miles east of Soledad	Not determined	Molybdenite in quartz occurs as north-south vein in granitic rock	Minor development by Vancouver Pinnacles Molybdenum Co., Aptos; no production. (Boalich 21:156–157; Laizure 25:50; herein.)
	(Unnamed)	Approx. SW¼ sec. 13, T. 20 S., R. 4 E., M.D., 16 miles west of King City	Not determined		Undeveloped prospect at Jackhammer Springs. (Herein).

PHOSPHATES

	Carmel Valley area	Sec. 29, T. 16 S., R. 2 E., M.D., 9 miles southeast of Monterey	Not determined	Two thin beds of pelletal phosphorite interbedded with siliceous shale of the Monterey Formation.	Not developed; exposed in 2 road cuts ½ mile apart. (Rogers 44:415; herein).
104	Reliz Canyon area	NW¼ sec. 13, T. 20 S., R. 6 E., M.D., 8 miles west of King City.	Not determined	Thin beds of pellatel phosphorite; within the Monterey Formation, occur through a stratigraphic interval of 2,000 feet.	Phosphorite beds have been traced 7–8 miles southeast of Reliz Canyon. Not developed. (Reed 27:195; Galliher 31:266; Thorup and Kleinpell 52: Fig. 4; herein).
105	San Lucas area	Sec. 15, T. 21 S., R. 9 E., M.D., 3 miles southeast of San Lucas.	Not determined	Phosphorite pebbles and pellets and phosphatized shells in Pancho Rico Formation.	Similar materials prospected 1961–1962 by Nicol Industrial Mineral Corp. in T. 20 S., R. 9 E., and T. 21 S., R. 10 E. (Bramlette and Daviess 44: text; herein).

SALT

Map No.	Name of claim, mine, or group	Location	Owner (Name, address)	Geology	Remarks and references
106	Monterey Bay Salt Works	E½ sec. 7, T. 13 S., R. 2 E., M.D., 1 mile north of Moss Landing.	D. L. Carpenter, Box 43 A, Moss Landing (1960)	....	Small, solar evaporation salt works operated continuously since 1916. (Waring and Bradley 19:614; Boalich 21:157; Laizure 25:53–54; Ver Plank 58:69–72; herein).

SAND & GRAVEL

Map No.	Name of claim, mine, or group	Location	Owner (Name, address)	Geology	Remarks and references
107	Bardin Ranch........	Sec. 20, T. 14 S., R. 4 E., M.D., 5 miles east of Salinas.	Bardin Ranch (1960)......	Small sand and gravel deposit in Alisal Creek. County tests indicate gravel is not suitable for portland cement concrete.	Used by County Road Department as imported subbase material in road construction.
108	Bardin Estate	S½ sec. 2, T. 15 S., R. 3 E., M.D., 2½ mile southeast of Salinas.	Martha E. Bardin Estate, Walter J. Schween, Trustee (1960)	Quaternary alluvium (fan?) composed of silty sand and gravel (15% gravel, 12% minus 200-mesh) at least 10 feet thick, deposited on Salinas River floodplain (?).	Pit developed by Gordon H. Ball and other (?) contractors 1951–1954. Used as imported base and concrete treated base for state highway. Nearby deposit of silty sand used as fine aggregate for portland cement concrete in state highway.
109	Big Sandy Creek.....	SW¼ sec. 17, T. 22 S., R. 13 E., M.D., 15 miles northeast of Bradley.	Hope S. Bagby (?), Hidden Valley Ranch, San Miguel (1960)	White, nearly unconsolidated sandstone of Santa Margarita Formation.	Undeveloped, except for small pits developed by ranchers for local use. Potential source of construction and specialty sand. (Wright 48:70, 72; herein under Older Formations).
110	Boyd..............	Center sec. 4, T. 20 S., R. 8 E., M.D., 1 mile northeast of King City.	David Boyd, 625 Bassett, King City (1960)	Stream channel (wash) and floodplain deposit of San Lorenzo Creek. Composed of 20% gravel and 10% minus 200-mesh. Gravels consist of Franciscan type rocks, with lesser amounts of granitic, volcanic and Tertiary sedimentary rock types.	Deposit developed by pits over a length of ¼ mile in and near present channel to depth of 10–15 feet. Material used by state for base, subbase, and concrete treated base in construction of U.S. Highway 101 near King City, 1954–1959. Apparently still active in 1961, but use unknown.
111	Brennan (McCool)...	NW¼ sec. 15, T. 22 S., R. 10 E., M.D., 1½ miles east of San Ardo.	Brennan (?) San Ardo (1949)	Stream channel deposit in Pancho Rico Creek. Gravel comprises 37–54% of deposit and minus 200-mesh comprises 6%. One-half mile downstream from Brennan pit, channel deposit was not extensive and gravel consisted of Franciscan rock types, granitic rocks, volcanics, sandstone, and siliceous and clay shales. About 50% was gravel to a maximum size of 3 or 4 inches.	Pit developed 1949 by Frederickson and Kasler, Contractors. Used by state as borrow and road base (?) materials for highway construction. Recent development not known.
112	Calera Canyon.......	N½ sec. 15, T. 16 S., R. 2 E., M.D., 10 miles southwest of Salinas.	Not determined..........	White to light gray, poorly consolidated, quartz-feldspar sandstone of the Santa Margarita Formation.	Developed by small pits only; apparently used by local ranchers, but no record of production. Potential source of construction or specialty sand. (Wright 48:70, 72; herein under Older Formations).
	California Glass Insulator Co.	Near Monterey............	Not determined..........	Dune sand................	Shipped several hundred tons of sand to Long Beach in 1913 for use in glass manufacture. (Waring and Bradley 19:614; Boalich 21:157). Possibly the same deposit that supplied the San Francisco glass industry since 1860's (Browne 68:251).
113	California Water and Telephone Co. (Los Padres Dam)	NE¼ sec. 8, T. 18 S., R. 3 E., M.D., 18 miles southeast of Carmel.	California Water and Telephone Co., 481 Tyler, Monterey (1961)	Recent stream gravel lying on Sur Series.	Earth dam (completed 1949) with a concrete spillway containing 6,808 cu. yds. of concrete made with with native aggregate from Carmel River stream bed. Also, 95,000 cu. yds. of native rock (Sur Series metamorphic and possibly some granitic rock) from dam site excavation used as rip rap and down stream ballast rock blanket.
114	California Water and Telephone Co. (San Clemente Dam)	SW¼ sec. 24, T. 17 S., R. 2 E., M.D., 14 miles southeast of Carmel.	California Water and Telephone Co., 481 Tyler, Monterey (1961)	Sand and gravel from stream channel deposits of Carmel River.	A concrete arch dam (completed 1921) containing 7,070 cu. yds. of concrete made with native aggregate.
	Carmel Development Co.	SE¼ sec. 14, T. 16 S., R. 1 W., M.D., just south of Carmel.	State of California (1960)	Coarse, feldspathic sand from Recent beach and dune deposit.	This company produced sand for use in glass manufacture and other purposes many years ago (Waring and Bradley 19:614; Laizure 25:54). The deposit is now part of the Carmel River Beach State Park and Bird Sanctuary.
	Cazin..............	....	....	....	See South Counties Sand and Gravel Co.
115	Clark..............	SE¼ sec. 23, T. 18 S., R. 6 E., M.D., 2 miles northwest of Greenfield.	Alfred H. Clark, Soledad (1960)	Extensive stream bed deposit of Arroyo Seco; composed of 30–40% gravel similar in lithology to Zabala deposit (which see) located 1 mile upstream. Deposit consists of braided stream channels covering a width of ½ mile. Little or no overburden.	Large pit developed by Granite Construction Co. 1956–1958. Sand and gravel used as base and concrete treated base materials and as aggregate in asphalt concrete for state highway construction. Material was crushed, screened and blended to specifications. Asphalt plant in poor repair remains at pit. Inactive 1961.

SAND & GRAVEL—Continued

Map No.	Name of claim, mine, or group	Location	Owner (Name, address)	Geology	Remarks and references
116	Del Monte Properties Co. — Fan Shell Beach	Near SE cor. sec. 33, T. 15 S., R. 1 W., M.D., 4 miles southwest of Pacific Grove.	Del Monte Properties Co., Sand Dept., 620 Market St., San Francisco (1961)	Recent sand dune deposit.	Important source of glass sand and other specialty sands since 1955. Dune sand from Moss Beach supplied sand prior to that. Plant located 1 mile south of Pacific Grove. Pacific Improvement Co. was predecessor of present operator. (Aubury 06:278; Waring and Bradley 19:614; Boalich 21:157; Leizure 25:54–55; Sampson and Tucker 31:440; Wright 48:44–45; Lenhart 52:100–103; Utley 53:90–92; Messner 54:5–8; Gay 57:547, 548, 560; herein under Quaternary Beach and Dune Deposits).
117	Del Monte Properties Co.—Sawmill Gulch	Sec. 26, T. 15 S., R. 1 W., M.D., 2 miles southeast of Pacific Grove.	Del Monte Properties Co., 620 Market St., San Francisco (1963)	Quaternary deposit of dune sand and granitic wash.	Developed by prospect pit and drill holes. Potential source of specialty sand. (Herein, under Quaternary Beach and Dune Deposits, Monterey Peninsula Area).
118	Eade	N½ sec. 14, T. 19 S., R. 9 E., M.D., 10 miles northeast of King City.	H. T. Eade, Lonoak (1960)	Recent stream channel deposit in San Lorenzo Creek. Consists of 50% gravel to 3 inches and 7% minus 200-mesh where developed.	Deposit operated intermittently in recent years and on small scale. Material is crushed and screened in portable plants by various contractors. Used mainly by state as imported base and road mix aggregate.
119	Ferrini	NW¼ sec. 17, T. 16 S., R. 3 E., M.D., 9 miles south of Salinas.	Not determined	Sand and fine gravel from small stream channel deposit on north fork of Watson Creek.	Material screened and used as base material and plant mix aggregate for county roads.
120	Gould	SW¼ sec. 15, T. 19 S., R. 6 E., M.D., 4½ miles southwest of Greenfield.	E. C. and F. E. Gould, Greenfield (1960)	Moderate-sized deposit of sand and gravel mapped as Paso Robles Formation, but may be younger stream terrace deposit. Gravel comprises about ½ of deposit and consists mainly of granitic and metamorphic rocks with some siliceous and diatomaceous shale and sandstone in the finer sizes. The sand is mainly quartz, feldspar and granitic fragments.	Developed by hillside pit 100 feet by 200 feet with maximum face of 50 feet. Used intermittently in recent years by County as road fill, but probably could be used for higher road construction purposes. Oversize boulders scalped from gravel are stockpiled and could be used as a small source of crushed rock. Pit was inactive in June 1960.
121	Granite Construction Co.	SW¼ sec. 15, T. 15 S., R. 1 E., M.D., in Sand City.	Granite Construction Co., Watsonville (1961)	Recent beach and dune sand.	Deposit operated since late 1940's as source of fine aggregate used in adjacent concrete and asphalt plants. Active 1961. (Herein, under Quaternary Beach and Dune Deposits).
122	Haber	SW¼ sec. 16, T. 16 S., R. 1 E., M.D., 3 miles southwest of Carmel.	E. H. Haber, Leased by Granite Construction Co., Watsonville (1960)	Sand and gravel from stream channel deposit, Carmel River.	Moderately large production 1959–1960. Supplied base materials in state highway and subdivision road construction. (Herein, under Quaternary Stream Deposits).
123	Hurt Ranch	SE¼ sec. 12, T. 15 S., R. 4 E., M.D., 5 miles northwest of Chualar.	Hazel Hurt, Salinas (1960)	Stream channel deposit of Quail Creek. Consists of 50% gravel, including 15% plus 3-inches. Pit not visited, but channel deposits just below appear insignificant in size.	Granite Construction Co., Watsonville, crushed material to minus ¾-inch for use as asphalt concrete aggregate in State highway construction 1951. Inactive 1961.
124	La Macchia	NW¼ sec. 29, T. 16 S., R. 6 E., M.D., 5½ miles east of Gonzales.	La Macchia Ranch (1960)	Sand and gravel from dry wash. Composed mainly of granitic debris. Channel deposit narrow and probably shallow.	County reportedly used as road mix aggregate.
	Lake Majella				Previous name for sand dune deposits near Moss Beach, formerly utilized by Del Monte Properties Co. (which see) and since 1943 by Owens-Illinois (which see).
	Lapis				See Pacific Cement and Aggregates, Inc.—Lapis.
	Machado				See Odello.
125	Metz	NE¼ sec. 21, T. 18 S., R. 7 E., M.D., at Metz	Samuel T. Mathews, Metz (1961)	Sand and gravel deposit in dry channel of Chalone Creek, east of Metz Rd. The percentage and sizes of gravel not determined, but probably slightly coarser than adjacent pit of South Counties Sand and Gravel Co. (which see for geology).	Pit operated by Metz Aggregate Co., a subsidiary of Granite Construction Co. of Watsonville, for 10 years prior to early 1959 when the operation was abandoned. The sand and gravel was washed, screened, scrubbed in a trommel, and crushed to minus one-inch. The sand was ground in a ball mill and classified to meet grading specifications. Material mainly used in local transit mix operation. When higher specifications required, crushed granitic rock from Logan was substituted for the coarse aggregate (e.g. in construction of Soledad Prison). The plant was active about 2 months per year and production was probably modest. Inactive and plant equipment removed.
126	Molera Ranch	NW¼ sec. 15 and NE¼ sec. 16, T. 19 S., R. 1 E., M.D., 4 miles northwest of Big Sur.	Mrs. Frank Molera, Big Sur (1961)	Stream channel and floodplain deposit on the Sur River. Coarse aggregate comprises a substantial part of the deposit which was derived from granitic and metamorphic rocks and some Franciscan type rocks. The aggregate appears to be sound	Developed by several pits and trenches as much as 15 feet deep. The excavations were made by Paul Woof in 1957, Granite Construction Co. in 1959–1960, and possibly others. The material used for the Point Sur Navy housing development was processed by portable equipment, but the details of this were not determined. Some of the sand and gravel also was used, without processing, as struc-

SAND & GRAVEL—Continued

Map No.	Name of claim, mine, or group	Location	Owner (Name, address)	Geology	Remarks and references
	Molera Ranch —Continued			and durable. Deposit in channel and banks average about 150 feet wide, one mile long, and more than 15 feet thick. Additional deposits may exist in wide floodplain near mouth of river.	tural backfill behind concrete cribbing along State Highway 1.
127	Monterey County (?).	SE¼ sec. 33, T. 19 S., R. 8 E., M.D., 2 miles northeast of King City.	Not determined (leased by Monterey County?) (1960)	Sand and gravel from terrace deposit of San Lorenzo Creek. Where developed, it consists of 40% gravel and 4% minus 200-mesh. Thin soil overburden. Gravel is rounded to subrounded and consist of Franciscan type rocks with lesser granitic, volcanic and Tertiary sedimentary rocks, including some soft and siliceous shales.	Developed by trench 300 x 50 x 15 feet. Used by county as source of subbase, crusher run base, and plant mix aggregate in construction of Bitterwater Road, 1948. Not active (?).
128	Monterey Sand Co. —Marina	Center sec. 24, R. 14 S., T. 1 E., M.D., 1 mile northwest of Marina.	Monterey Sand Co., Box 928, Monterey (1961)	....	Beach sand deposit and plant; operated continuously since about 1944. (Herein under Quaternary Beach and Dune Deposits).
129	Monterey Sand Co.—Sand City	SW¼ sec. 15, T. 15 S., R. 1 E., M.D., in Sand City.	Monterey Sand Co., Box 928, Monterey (1961)	....	Beach and dune sand deposit worked at least as early as 1931 by Sydney Ruthven. The present owner operated deposit and sand plant since 1946. (Pit and Quarry 49: 83–84; Gay 57:517; herein, under Quaternary Beach and Dune Deposits).
130	Monterey Sand Co.—San Jose Creek	SE¼ sec. 23 T. 16 S., R. 1 W., M.D., 2 miles south of Carmel.	State of California (1960)	Beach and dune sand deposit at mouth of San Jose Creek. Deposit consists of very coarse grains of quartz, feldspar, and granitic debris piled in drifts as much as 15–20 feet high.	Developed to a minor extent in the early 1950's by Monterey Sand Co. for use as filtration sand. The sand was processed at the company's Sand City plant. Deposit is inactive and now part of the Carmel River Beach State Park and Bird Sanctuary.
131	Morse............	SE¼ sec. 29, T. 16 S., R. 2 E., M.D., 9 miles east of Carmel in Carmel Valley.	Morse property (1960)	Stream channel deposit of Carmel River. Sand and gravel mainly of granitic composition; contains 45% gravel and 3% minus 200-mesh.	Pit located ½ mile west of Los Laurelles Grade Rd.; developed by Madonna Construction Co. under state contract. Material crushed and used as imported base and asphalt concrete aggregate in construction of Los Laurelles Grade Road, 1959–1960. Some material also stockpiled for county use as base material and road mix aggregate 1959–1960. Inactive late 1960.
	Murphy............	....	....	....	See Valley Rock and Adobe Co.
132	Odello............	SE¼ sec. 13, T. 16 S., R. 1 W., M.D., 1 mile southeast of Carmel.	Bruno Odello, Carmel, leases to Monterey Sand Co., Box 928, Monterey (1960)	Sand and gravel in stream channel of Carmel River.	Deposit worked intermittantly since 1927, first by a man named Machado and most recently by Monterey Sand Co. (Herein, under Quaternary Stream Deposits).
133	Otey............	SW¼ sec. 13, T. 16 S., R. 1 W., M.D., one mile south of Carmel.	Not determined.........	Sand from channel or floodplain of Carmel River.	Albert Otey produced plaster sand from pit near mouth of river in the 1920's. The sand was not processed, but was shovelled directly into trucks for marketing. (Laizure 25:57; Sampson and Tucker 31:441).
134	Owens-Illinois—Moss Beach (Lake Majella)	SE¼ sec. 22, T. 15 S., R. 1 W., M.D., 2 miles southwest of Pacific Grove.	Owens-Illinois 350 Sansome Street, San Francisco (1961)	Recent dune sand............	Used since 1943 as source of feldspathic glass sand. Company processes at a nearby sand plant for shipments to Oakland factory. (Wright 48:44; Gay 57:548, 562; herein, under Quaternary Beach and Dune Deposits). North part of deposit worked by Pacific Improvement Co. 1903–1920 and Del Monte Properties Co. (which see) 1921–1955 until depleted (Aubury 06:278; Waring and Bradley 19:614; Boalich 21:157; Laizure 25:54–55; Sampson and Tucker 31:440).
135	Pacific Cement and Aggregates, Inc.—Lapis	E½ sec. 13, T. 14 S., R. 1 E., M.D. 2 miles north of Marina.	Pacific Cement and Aggregates, Inc., 400 Alabama St., San Francisco (1961)	....	Beach and dune sand deposits worked by E. B. and A. L. Stone (1906–1918); Bay Development Co. (1918–1928); and present owner (since 1928). Material is processed at nearby plant. (Waring and Bradley 19:614–615; Laizure 25:55; Sampson and Tucker 31:441; Wright 48:45–46; Gay 57:548, 553; herein, under Quaternary Beach and Dune Deposits).
136	Pacific Cement and Aggregates, Inc. —Prattco	N½ sec. 15, T. 15 S., R. 1 E., M.D., 1 mile north of Seaside.	Pacific Cement and Aggregates, Inc., 400 Alabama St., San Francisco (1961)		Beach and dune sand deposit operated by Pratt Building Materials Co. since 1921 and by the present owner since 1929. (Laizure 25:55–56; Sampson and Tucker 31:441; Gay 57:548; herein, under Quaternary Beach and Dune Deposits).
	Pacific Improvement Co.	....	....	....	See Del Monte Properties Co. and Owens-Illinois.
	Pratt Building Materials Co. (Prattco)	....	....	....	See Pacific Cement and Aggregates, Inc.—Prattco.
	Prattco Sand Pit No. 4	....	....	....	See Pacific Cement and Aggregates, Inc.—Prattco.
137	Seaforth Corp........	W½ sec. 25, T. 14 S., R. 1 E., M.D., one mile southwest of Marina.	Seaforth Corp., Dewitt Rucker, Pres., Box 314, Pebble Beach (1960)	Large Recent dune deposit.......	Company owns 200 acres of dunes just north of Fort Ord. A moderate amount of sand was produced in 1959 and 1960 mainly for use as fill. The owner reports land is to be subdivided for housing development.

SAND & GRAVEL—Continued

Map No.	Name of claim, mine, or group	Location	Owner (Name, address)	Geology	Remarks and references
138	Seaside Sand and Gravel Co.	NW$\frac{1}{4}$ sec. 24, T. 14 S., R. 1 E., M.D., one mile northwest of Marina.	Seaside Sand and Gravel Co., Inc., P.O. Box 513, Marina (1961)	....	Beach sand obtained and processed at nearby plant since 1957. (Calif. Div. Mines 58: 11–12; herein, under Quaternary Beach and Dune Deposits.)
139	South Counties Sand & Gravel Co. (Cazin)	NE$\frac{1}{4}$ sec. 21, T. 18 S., R. 7 E., M.D., $\frac{1}{2}$ mile south of Metz	South Counties Sand & Gravel Co., (A. B. Woodward, owner), Metz (1961)	....	Small sand and gravel operation at mouth of Chalone Creek. Formerly owned by Max Cazin. (Herein, under Quaternary Stream Deposits.)
140	Titus...............	NE$\frac{1}{4}$ sec. 2, T. 16 S., 2 E., M.D., 7 miles southwest of Salinas	T. W. Titus, 240 Benancio Rd., Salinas (1960)	Poorly-consolidated conglomerate (fanglomerate?) of the Paso Robles Formation. Consists of angular debris derived from granitic and metamorphic rocks. The material is mainly sand.	Pit developed 1945–1955 by several contractors who used material as subbase in state road construction. Two other inactive pits in similar material located nearby to the east and southeast. (Also see herein under Older Formations.)
141	Turkey Flat..........	S$\frac{1}{4}$ cor., sec. 32, T. 23 S., R. 15 E., M.D., 3 miles southeast of Parkfield	Not determined.........	Stream terrace deposit consisting of interbeds of sand and gravel. At the pit, the gravel comprises about 50% of the material and consists of serpentine, silica-carbonate rock and Franciscan rock types.	Developed by a pit 50 feet by 100 feet by 12–14 feet. Although no equipment was at pit when visited April 1960, it is apparent pit was operated recently. The use of the material is not known, but it would appear to be restricted to use as fill or subbase material.
142	U.S. Army (Nacimiento River)	E$\frac{1}{2}$ sec. 32, T. 23 S., R. 7 E., M.D., 6$\frac{1}{2}$ miles southwest of Jolon	U.S. Army, Hunter-Liggett Military Reservation (1961)	Sand and gravel deposit in stream channel and floodplain of Nacimiento River. Deposit is large, being at least 100 yards wide and a mile long. Gravel comprises about 50% of material at pit and consists of granitic and metamorphic rocks with minor sandstone and some Franciscan rock types. The material appears to be of good quality and probably suitable for use as concrete aggregate. Similar material occurs over a distance of 20 miles upstream from the county boundary.	Developed by small pit 8–10 feet deep in floodplain. Material used by U.S. Army for unknown purposes.
143	U.S. Army (San Antonio River)	SW$\frac{1}{4}$ sec. 29, T. 22 S., R. 7 E., M.D., 4 miles west of Jolon	U.S. Army, Hunter-Liggett Military Reservation (1961)	Sand and gravel in stream channel of San Antonio River. Deposit is about 100 feet wide, over 10 feet thick and more than $\frac{1}{2}$ mile long. It contains 50% gravel to a maximum size of 3 or 4 inches. Gravel is predominantly composed of granitic and metamorphic rocks, with lesser sandstone and siliceous and soft shales.	Developed extensively in vicinity of bridge for use at military reservation. No equipment at excavation site, but active in recent years.
144	Valley Rock and Adobe Co. (Murphy)	SE$\frac{1}{4}$ sec. 24, T. 16 S., R. 1 E., M.D., 6 miles east of Carmel	Valley Rock and Adobe Co. (John B. Simpson, owner), P.O. Box 64, Carmel Valley (1961)	....	Sand and gravel obtained from stream channel of Carmel River from about 1920 to 1955 by M. J. Murphy and since 1955 by present owner. (Herein, under Quaternary Stream Deposits.)
145	Wolter............	NE$\frac{1}{4}$ sec. 21, T. 16 S., R. 1 E., M.D., 4 miles southeast of Carmel	Luis F. Wolter, Carmel Valley, leases to Phil Calabrese, Contractor, Sand City (1961)	....	Stream channel deposit on Carmel River, worked intermittently since about 1950 as source of road materials. (Herein, under Quaternary Stream Deposits.)
146	Zabala............	W$\frac{1}{2}$ sec. 35, T. 18 S., R. 6 E., M.D., 2 miles west of Greenfield	Walter Zabala, Greenfield (1960)	....	Large dry wash channel deposit in Arroyo Seco; developed 1959–1960 by Delphia-Early under a contract with the State Division of Highways. (Pacific Roadbuilder and Engrg. Rev. 59:15–16; herein under Quaternary Stream Deposits.)

SILVER

Map No.	Name of claim, mine, or group	Location	Owner (Name, address)	Geology	Remarks and references
	Alisal.............	Not determined. (Possibly W$\frac{1}{2}$ sec. 9, T. 14 S., R. 4 E., M.D.)	Not determined. (Sec. 9 owned by D. F. Davies, 1029 Old Stage Rd., Salinas) (1966)	....	Early silver prospect. (Duflot de Mofras 1844; Trask 1854:18, 55-56; Blake 1858:295, 301, 303; Bancroft 1886:144, 176; Waring and Bradley 19:615; Laizure 25:23, 56; Goodwin 57:571, herein).

STONE—CRUSHED & BROKEN

Map No.	Name of claim, mine, or group	Location	Owner (Name, address)	Geology	Remarks and references
147	Arroyo Seco........	NE$\frac{1}{4}$ sec. 2, T. 20 S., R. 4 E., M.D., 16 miles southwest of Greenfield	U.S. Forest Service (1960)	Decomposed granite, reportedly..	Reportedly developed by several pits which provide base materials and plant mix aggregate for road construction in and around the Arroyo Seco campground of the U.S. Forest Service. Active 1960 (?).

STONE—CRUSHED & BROKEN—Continued

Map No.	Name of claim, mine, or group	Location	Owner (Name, address)	Geology	Remarks and references
148	Atkinson (Morrison-Knudson)	SE¼ sec. 25, T. 15 S., R., 1 W., M.D., in Monterey	Not determined	Relatively unweathered granodiorite.	Large quarry developed by Guy Atkinson and Morrison-Knudson(?) construction firms as a source of riprap ("B" and "C" type breakwater stone). Material used by U.S. Army Corps of Engineers to construct breakwater at Monterey harbor. Inactive. (Herein).
149	Augustini	SE cor. sec. 13, T. 13 S., R. 3 E., M.D., 4 miles southwest of San Juan Bautista	Augustini (?) property	Decomposed granite, considered to be of poor quality by County Road Department.	Developed by small hillside pit. Material used as imported borrow by county intermittently in past. Minor recent production apparently was for local private construction.
	Bardin Ranch	NW¼ sec. 11, T. 15 S., R. 4 E., M.D., 8 miles east of Salinas	Walter Bardin, Salinas (1960)	Relatively unweathered granodiorite.	Developed by small prospect pits along creek bottom. No commercial production, but potential source of crushed and broken stone.
150	David Avenue	SW¼ sec. 24, T. 15 S., R. 1 W., M.D., near Nine Ponds Park, Pacific Grove	Phil Calabrese, contractor (1960)	Decomposed granite	Developed by large pit behind Safeway store. Material used as base material and fill in road construction for County and Berwick Manor subdivision. Excavation appears to be part of a land leveling operation.
151	De Amaral—Carmel Highlands	Near E¼ cor. sec. 26, T. 16 S., R. 1 W., M.D., ½ mile northeast of Carmel Highlands	Frank De Amaral, contractor (1961)	Decomposed granite	Developed by hillside pit; supplies road base materials in Carmel Highlands area. Active in early 1961 and for at least 10 years prior to that.
152	De Amaral—Carmel Valley	N¼ cor. sec. 35, T. 16 S., R. 2 E., M.D., 1½ miles northeast of Robles del Rio	Frank de Amaral, contractor (1960)	Decomposed granite	Reportedly used for road base materials in construction of Del Monte No. 10 subdivision about 1957.
153	Del Fino	SE¼ sec. 11, T. 17 S., R. 2 E., M.D., in Carmel Valley ½ mile south of Camp Steffani	Not determined	Decomposed granite overlain by 10 to 30 feet of terrace sand and gravel of granitic composition. Degree of decomposition is variable	Developed by pit 300 feet long with maximum face of 75 feet. Material used as road base by county in construction of Airway road in Carmel Valley in 1955. Also some private use. Inactive.
154	Del Monte Properties Co.	NE¼ sec. 35, T. 15 S., R. 1 W., M.D., 2 miles north of Carmel	Del Monte Properties Co., Road Dept., Pebble Beach (1959)	Decomposed granite with a few "hard spots."	Developed by pit approximately 300 by 900 feet with a 40- or 50-foot face at the southeast end. For many years, this has been a major source of base material and bituminous "aggregate" for secondary road construction on the Monterey Peninsula. Present operations consist of excavation with a ripper and bulldozer, scalping of plus 7-inch material over a grizzly, and crushing to minus 2 inches. Oversize material is only partly weathered and is sold as wall rock and rubble (also see under Stone—Dimension).
155	Del Monte Properties Co.	SW¼ sec. 25, T. 15 S., R. 1 W., M.D., 2 miles south of Pacific Grove	Del Monte Properties Co., Road Dept., Pebble Beach (leased to Calif. Div. of Highways) (1960)	Decomposed granite with numerous "hard spots." Weathering effects decrease rapidly with depth and below 68 feet, granitic rock is considered to be a potential source of crushed and broken stone. Overlain by friable, arkosic sandstone averaging 13 feet thick at the pit face.	Moderately large pit operated intermittently for many years as a source of road base materials. Monterey County used in 1955. State used as a source of base and concrete treated base in 1960–1961; crushing necessary. Oversize blocks from "hard spots" used as riprap along Salinas River. Pit is about 250 ft. by 75 ft. with maximum face of 40–50 ft.
156	Echo Valley	S½ sec. 4, T. 13 S., R. 3 E., M.D., 2 miles northeast of Prunedale	Not determined	Decomposed granite	Developed by 3 small pits along Echo Valley Road. Material used as local source of fill and possibly as road base material. Two of the pits were active in 1960.
157	Fleming	N½ sec. 28, T. 16 S., R. 2 E., M.D., north of Carmel Valley	Not determined	Decomposed granite	Material used by county in 1956 as base material for construction of Los Laurelles Grade Road. Also some private use.
158	Haldorn	SW¼ sec. 21, T. 16 S., R. 2 E., M.D., 8 miles southeast of Seaside	Not determined	Decomposed granite	Developed by hillside pit measuring 200 feet by 300 feet with maximum relief of 75 feet (in 2 benches). Material used extensively by the state and county as a source of road base materials.
	Hatton Ranch	Approx. NE¼ sec. 13, T. 16 S., R. 1 E., M.D., in Carmel Valley	Not determined	Decomposed granite	Pit located about one mile east of Carmel. Material used prior to 1925 for walks, roads and driveways. (Laizure 25:57.)
159	Henningsen	S½ sec. 35, T. 15 S., R. 3 E., M.D., 3½ miles southeast of Spreckels	E. A. Henningsen, contractor (1960)	Decomposed granite with high clay content	Developed by irregular pit 200 feet by 400 feet with maximum depth of 20–30 feet. Source of road construction materials. Last active 1958.
	Henningsen	Center sec. 27, T. 15 S., R. 3 E., M.D., 2 miles southeast of Spreckels	E. A. Henningsen, contractor (1960)	Reported to be decomposed granite, but mapped as Quaternary terrace deposit.	Reportedly used as road subbase material. Pit not located.
160	Hill	NE¼ sec. 33, T. 18 S., R. 1 E., M.D., 7 miles northwest of Big Sur	C. T. Hill, P.O. Box 1588, Monterey (1960)	Very hard and durable Franciscan sandstone. Broken stone at the quarry ranges in size up to several tons, but most pieces are small indicating that rock is considerably fractured. Los Angeles Rattler Test showed 22.9% loss at 500 revolutions.	Developed by a small hillside quarry on south side of Little Sur River. Material used as a source of "light stone" rip rap in highway slope protection by the State in 1959 or 1960. Also, previous use of stone locally.

STONE—CRUSHED & BROKEN—Continued

Map No.	Name of claim, mine, or group	Location	Owner (Name, address)	Geology	Remarks and references
161	Jefferson Street	NE¼ sec. 25, T. 15 S., R. 1 W., M.D., in city of Monterey at end of Jefferson St.	Not determined	Decomposed granite overlain by as much as 50 feet of terrace gravels consisting of granitic debris and some shale from the Monterey Formation	Large irregular pit recently active, but future development limited by recreational and urban development. Use of material unknown.
	Johnson	SW cor. sec. 1, T. 16 S., R. 4 E., M.D., 1½ miles east of Chualar	Gottlob Johnson, P.O. Box 164, Chualar (1960)	Reported to be decomposed granite	Pre-existing pit developed to provide base and subbase materials for construction of state highway in 1950's.
162	Mee Ranch	S½ sec. 9, sec. 14, and SW¼ sec. 16, T. 20 S., R. 11 E., M.D., 14 miles northeast of San Lucas	Mee Ranch, Peach Tree Valley (1959)	Red chert and greenstone masses associated with other rocks of the Franciscan Formation, all of which has been badly faulted and crushed within the San Andreas fault zone	Developed by 3 small pits, 2 being in chert and a third in greenstone. Material used locally by state and others as source of road construction materials, including bituminous aggregate. Pits intermittently active for many years.
74	Natividad	Secs. 35 and 36, T. 13 S., and secs. 1 and 2, T. 14 S., R. 3 E., M.D., 6 miles northeast of Salinas	Kaiser Aluminum and Chemical Corp., 300 Lakeside Drive, Oakland (1960)	Large pendant of crystalline dolomite cut by dikes of partly decomposed granitic rock	Decomposed granite and dolomite fines from the grizzly separation at the dolomite plant are used occasionally by the county as subbase material for road construction. These products are normally wasted at the quarry. A potential source of crushed aggregate is the slightly impure dolomite presently being wasted at the heavy media separation section. Other stone products obtained from this deposit include white roofing and landscape granules. (Discussed herein; also see under Limestone and Dolomite.)
163	O'Brien	NW¼ sec. 29, T. 16 S., R. 6 E., M.D., 5½ miles east of Gonzales	Not determined	Decomposed granite	Reportedly developed by pit and used intermittently by county as a source of base and subbase materials for road construction.
164	Rianda	NW¼ sec. 3, T. 16 S., R. 3 E., M.D., in Pine Canyon 3½ miles south of Spreckels	A. V. Rianda, Jr., 223 Main St., Salinas (1960)	Decomposed granite; evenly and deeply weathered	Developed by a large pit 300 feet by 900 feet with a maximum face of 150 feet. A major source of road base materials in the Salinas-Monterey area. Material was used by the state and county intermittently from 1952 to 1957.
165	Rianda	NE¼ sec. 23, T. 19 S., R. 8 E., M.D., 5 miles northeast of King City	John Rianda, King City (1960)	Decomposed granite	Reportedly developed intermittently to supply base materials for county roads.
166	Ruthven	SW¼ sec. 25, T. 15 S., R. 1 W., 1½ miles south of Pacific Grove	Not determined	Decomposed and partly decomposed granite	Fair-sized pit developed by Sydney Ruthven about 1932–1933. Use of material not known, but material appears to be less weathered than most decomposed granite. Pit not active in many years.
167	Sawyer (Riley; Highland)	NE¼ sec. 2, T. 17 S., R. 1 W., M.D., near Carmel Highlands ½ mile east of highway.	Sawyer property, Carmel Highlands (1959)	Decomposed granite, reported to have high clay content.	Developed by 2 pits; operated recently by Granite Construction Co. and Frank DeAmaral, contractors, for various local construction. Previously, material was blended with Carmel River sand for use as subbase in 1952 construction of State Highway 1. County also used material as road base until about 1957. South pit is small; north pit developed by 3 benches totalling 100' in relief.
168	Sillacci (Spreckels)—lower quarry	NE¼ sec. 30, T. 14 S., R. 4 E., M.D., 5 miles east of Salinas.	Sillacci Ranch (1960)	Small mass of crystalline limestone cut by dikes of weathered granitic rock.	Developed by narrow quarry about 200 yards long with a maximum face of 30–35 feet. Limestone was quarried at the turn of the century by Spreckels Sugar Co. who used it in sugar refining or as a source of crushed and broken stone (see Spreckels, under Limestone and Dolomite). More recently the limestone and granite were crushed to a minus ¾-inch size for use as a crusher-run subgrade in construction of a state highway.
169	(Unnamed)	SW¼ sec. 8, T. 21 S., R. 8 E., M.D., 6½ miles south of King City.	Not determined	Sequence of thinly-bedded, highly-fractured, siliceous shales of the Monterey Formation.	Large quarry at intersection of Jolon and San Lucas roads. Reportedly used by county as a source of borrow and road subbase materials. Recently active.
170	(Unnamed)	NW¼ sec. 10, T. 13 S., R. 3 E., M.D., 2 miles northeast of Prunedale on U.S. Highway 101.	Not determined	Decomposed granite overlain by as much as 30 feet of Aromas red sand.	Old pit; probably last active in early 1940's (Allen 46:73). Use not known.
171	(Unnamed)	NW¼ sec. 25, T. 13 S., R. 3 E., M.D., 7½ miles northeast of Salinas on San Juan Grade road.	Not determined	Decomposed granite overlain by gently-dipping terrace gravels as much as 25 feet thick.	Developed by pit 100 feet by 500 feet by 25 feet. Not operated for many years. (Allen 46:73).

STONE—DIMENSION

Map No.	Name of claim, mine, or group	Location	Owner (Name, address)	Geology	Remarks and references
172	Carmel Stone quarries (Anthony)	W½ sec. 16, T. 16 S., R. 1 E., M.D., 3 miles east of Carmel	Not determined	Buff to brown, massive beds of siliceous shale interbedded with thinly-bedded diatomacious shale of the Monterey Formation. These beds strike N 65° W and dip 30° S.	From about 1927 to 1932, a series of small quarries were developed by Arthur Anthony. The stone produced was used mainly as patio and building stone of good structural quality (Galliher 32:25–27). Inactive for many years.

STONE—DIMENSION—Continued

Map No.	Name of claim, mine, or group	Location	Owner (Name, address)	Geology	Remarks and references
173	Carmel Stone quarry (Passadori)	SE¼ sec. 16, T. 16 S., R. 1 E., M.D., 3½ miles east of Carmel.	Dormady Equipment & Supply Co., Rt. 2, Box 940, Carmel (1960)	....	Quarry first developed in 1935 by A. L. Passadori who reportedly obtained the property from Arthur Anthony. Since 1956, the property has been operated by Porter-Marquard Realty, Leo E. Alexander, and the present operator. (Calif. Div. of Mines 54:6–7; Goldman 57:601, 604; herein).
(154)	Del Monte Properties Co.	NE¼ sec. 35, T. 15 S., R. 1 W., M.D., 2 miles north of Carmel.	Del Monte Properties Co., Road Dept., Pebble Beach (1959)		Granodiorite rubble produced as a byproduct from a large decomposed granite pit operation. (Discussed herein; also see under Stone—Crushed & Broken).
	Machado..........	Near W¼ cor. sec. 19, T. 16 S., R. 1 E., M.D., 2 miles southeast of Carmel.	Stuyvesant Fish Ranch, Carmel Valley (1959)	Diatomaceous or siliceous Monterey shale.	A man by this name reportedly produced some "chalk rock" in 1920–1921 for use in the War Memorial Building and other structures in Carmel. The quarry is located at an elevation of about 500 feet and can be seen from Carmel Valley near State Highway 1. Another quarry or prospect about 500 feet to the west can be seen in the same sequence of beds.
	Meadows..........	Sec. 24, T. 16 S., R. 1 E., M.D., 6½ miles east of Carmel.	Not determined.........	Diatomaceous and siliceous shale of the Monterey Formation.	Mr. R. E. Meadows of Carmel Valley reportedly quarried "chalk rock" in Berwick and Buckeye Canyons many years ago. Several minor quarries or prospects observed in this area indicate that production was small. Inactive. This development may be the same as Meadows Gulch (which see).
	Meadows Gulch	Approx. sec. 19, T. 16 S., R. 2 E., M.D., 7 or 8 miles east of Carmel.	Not determined.........	Siliceous shale of Monterey Formation.	Albert Otey reportedly produced "chalk rock", beginning in 1921, from Meadows Gulch on property owned by James Meadows. The stone was used for veneering and flagging (Laizure 25:57; Sampson and Tucker 31:441). Possibly the same as Meadows (which see).
	Murphy...........	Not determined.............	Not determined.........	Monterey Formation...........	Unpublished records show that M. J. Murphy produced some building stone in 1929. The stone probably came from the Carmel Valley area.
	Passadori..........	....	....	....	See Carmel Stone quarry (Passadori).
	Ryon Rock.........	Not determined.............	Not determined.........	Monterey Formation (?).........	Unpublished records show that C. A. Ryon produced a small amount of building stone in 1927.
174	Santa Lucia Quarries, Ltd.	NW¼ sec. 21, W½ sec. 29, E½ sec. 30, T. 16 S., R. 1 E., M.D.	San Carlos Ranch, Carmel Valley (1960)	Siliceous and diatomaceous shales and sandstone of the Monterey Formation.	A company by this name produced a substantial amount of patio stone, flagstone, building stone, and wall rock from about 1930 to 1932. The stone came from a long, sinuous quarry (upper quarry) in sec. 29 and 30 and a quarry in sec. 21 (lower quarry) (Galliher 32:21–27). Other stone quarries are located nearby in SE¼ sec. 28. It is not known if the stone obtained from these latter quarries was produced by Santa Lucia Quarries, Ltd. or another operator. None of the above quarries have been worked in recent years.
175	Sierra.............	SE¼ sec. 15, T. 16 S., R. 1 E., M.D., 4½ miles east of Carmel	L. S. Williams, Rt. 2, Box 690, Carmel (1960)	Buff-colored, siliceous siltstone or shale in Monterey Formation, locally overlain by terrace gravel. Beds dip about 20° SW.	Two or 3 quarries developed by H. E. Rogers 1928–1942. A substantial amount of patio stone, flagstone, building stone, and wall rock were produced (Galliher 32:25–27). About 1944–1945, Fred Ammerman is reported to have worked these quarries briefly, but there is no record of production by him. The quarries have lain idle since then.
(81)	Spreckels..........	Probably NE¼ sec. 20, T. 14 S., R. 4 E., M.D.	Sillacci Ranch (1960).....	White, crystalline limestone......	According to Aubury (06:73), Spreckels Sugar Co. produced rubble for use in buildings in Salinas 1899–1903. (See under Limestone and Dolomite; also see Sillacci under Stone—Crushed & Broken).
176	Stewart............	W½ sec. 15, T. 16 S., R. 1 E., M.D., 4 miles east of Carmel.	Mrs. Stewart, Carmel Valley Rd. at Canyon Segundo (1961)	Siliceous shale of the Monterey Formation.	Several small quarries on the east side of Canyon Segundo were developed intermittently 1929–1946 by Andrew Stewart. His total production was small and apparently included veneer and building stone, some of which was used to construct the Stewart residence. The quarries have not been operated recently.
	Tassajara Hot Springs	Near Tassajara Hot Springs....	Not determined.........	Gray to olive colored sandstone, probably of Eocene or Oligocene age.	Material quarried for use as building stone in the construction of the hotel at the hot springs prior to 1896. (Crawford 96:636; Aubury 06:131; Laizure 25:56–57).
	Whaler's Cove......	SW¼ sec. 23, T. 16 S., R. 1 W., M.D., at Point Lobos.	State of California (1960)	Porphyritic granodiorite.........	Personnel at Point Lobos State Park report this to be an old source of building stone.
177	Yost.............	NE¼ sec. 11, T. 23 S., R. 9 E., M.D., 6 miles southwest of San Ardo.	Harold Yost, General delivery, King City (1960)	....	Small production of Monterey shale in 1959 by Harold Yost and Bill Young. (Herein).

TUNGSTEN

Map No.	Name of claim, mine, or group	Location	Owner (Name, address)	Geology	Remarks and references
	Schmidt and Ortner prospect	NW¼ sec. 28, T. 17 S., R. 7 E., M.D., 6 miles east of Soledad.	August Schmidt, Star Rte. 3, Soledad, and a Mr. Ortner (1959).	....	Prospect reported to contain scheelite. No known development. (Herein).

URANIUM & THORIUM

Map No.	Name of claim, mine, or group	Location	Owner (Name, address)	Geology	Remarks and references
178	Aronjo Ranch prospect	SE¼ sec. 13, T. 23 S., R. 13 E., M.D., 6 miles northwest of Parkfield.	Aronjo Ranch, Parkfield (1955)	Thin coatings of carnotite on fractures in altered tuff.	Minor prospect. (Herein).
	Arroyo Seco area....	Near east line of T. 20 S., R. 4 E., M.D.	Not determined....	Radioactivity probably due to monazite in granitic and metamorphic rocks.	Minor development. (Herein).
	Chews Ridge area....	Sec. 6 and 29, T. 19 S., R. 4 E., M.D.	Not determined...... ..	Radioactivity probably due to monazite in granitic and metamorphic rocks.	Minor development. (Herein).

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△ 66133—650 3-66 3,500

Arsenopyrite
molybdenum

DIVISION OF MINES AND GEOLOGY
IAN CAMPBELL, STATE GEOLOGIST

STATE OF CALIFORNIA
THE RESOURCES AGENCY
DEPARTMENT OF CONSERVATION

STATE OF CALIFORNIA
THE RESOURCES AGENCY
DEPARTMENT OF CONSERVATION

COUNTY REPORT 5
PLATE 1

GEOLOGIC MAP OF MONTEREY COUNTY, CALIFORNIA

SHOWING MINES AND MINERAL DEPOSITS

COMPILED BY EARL W. HART

Geology adapted from Geologic Map of California, Olaf P. Jenkins edition: Santa Cruz Sheet (compiled by C. W. Jennings and R. G. Strand, 1958) and San Luis Obispo Sheet (compiled by C. W. Jennings, 1958)

Scale 1:250,000

5 0 5 10 15 20 Statute Miles

5 0 5 10 15 20 25 30 Kilometers

SYMBOLS

Faults (dashed where approximately located).

Depositional and intrusive contacts between units (dashed where approximately located).

• 124 Mines and mineral deposits

Oil fields

SUBMARINE CONTOUR INTERVAL 300 FEET

Submarine contours adapted from Shepard and Emery, 1941 (Geol. Soc. America Special Paper 31).
Base map data from Santa Cruz and San Luis Obispo topographic maps prepared by the Army Map Service and sold by the U. S. Geological Survey.

SECTIONIZED TOWNSHIP

6	5	4	3	2	1
7	8	9	10	11	12
18	17	16	15	14	13
19	20	21	22	23	24
30	29	28	27	26	25
31	32	33	34	35	36

EXPLANATION

SEDIMENTARY AND METASEDIMENTARY ROCKS

CENOZOIC — QUATERNARY — Recent
- Qs — Sand dunes (Qso = older sand dunes)
- Qal — Alluvium
- Qt — River terrace and fan deposits

Pleistocene
- Qm — Pleistocene marine and marine terrace deposits
- Qc — Pleistocene nonmarine

TERTIARY
- QP — Plio-Pleistocene nonmarine

Pliocene
- Pc — Undivided Pliocene nonmarine
- Pml — Middle and/or lower Pliocene marine

Miocene
- Mc — Undivided Miocene nonmarine
- Mu — Upper Miocene marine
- Mm — Middle Miocene marine
- Mmc — Middle Miocene nonmarine
- Ml — Lower Miocene marine

Oligocene
- Oc — Oligocene nonmarine
- O — Oligocene marine

Eocene
- E — Eocene marine

Paleocene
- Ep — Paleocene marine

MESOZOIC — CRETACEOUS
- K — Undivided Cretaceous marine
- Ku — Upper Cretaceous marine
- Kl — Lower Cretaceous marine

JURASSIC
- Jk — Knoxville Formation

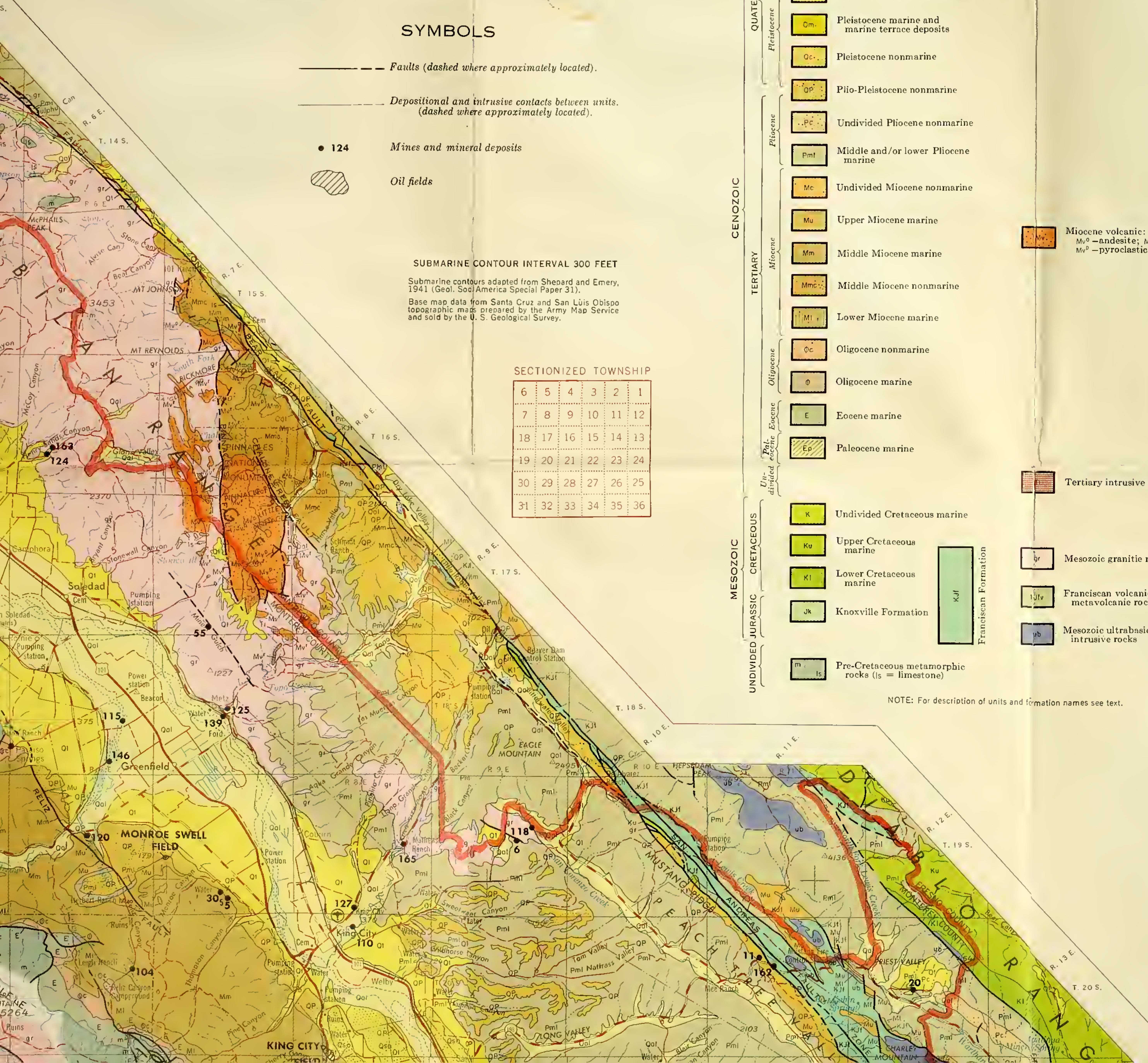
KJf — Franciscan Formation

UNDIVIDED
- m — Pre-Cretaceous metamorphic rocks (ls = limestone)

IGNEOUS AND META-IGNEOUS ROCKS

- Mv — Miocene volcanic: Mv^r —rhyolite; Mv^a —andesite; Mv^b —basalt; Mv^p —pyroclastic rocks
- Ti — Tertiary intrusive rocks
- gr — Mesozoic granitic rocks
- KJfv — Franciscan volcanic and metavolcanic rocks
- ub — Mesozoic ultrabasic intrusive rocks

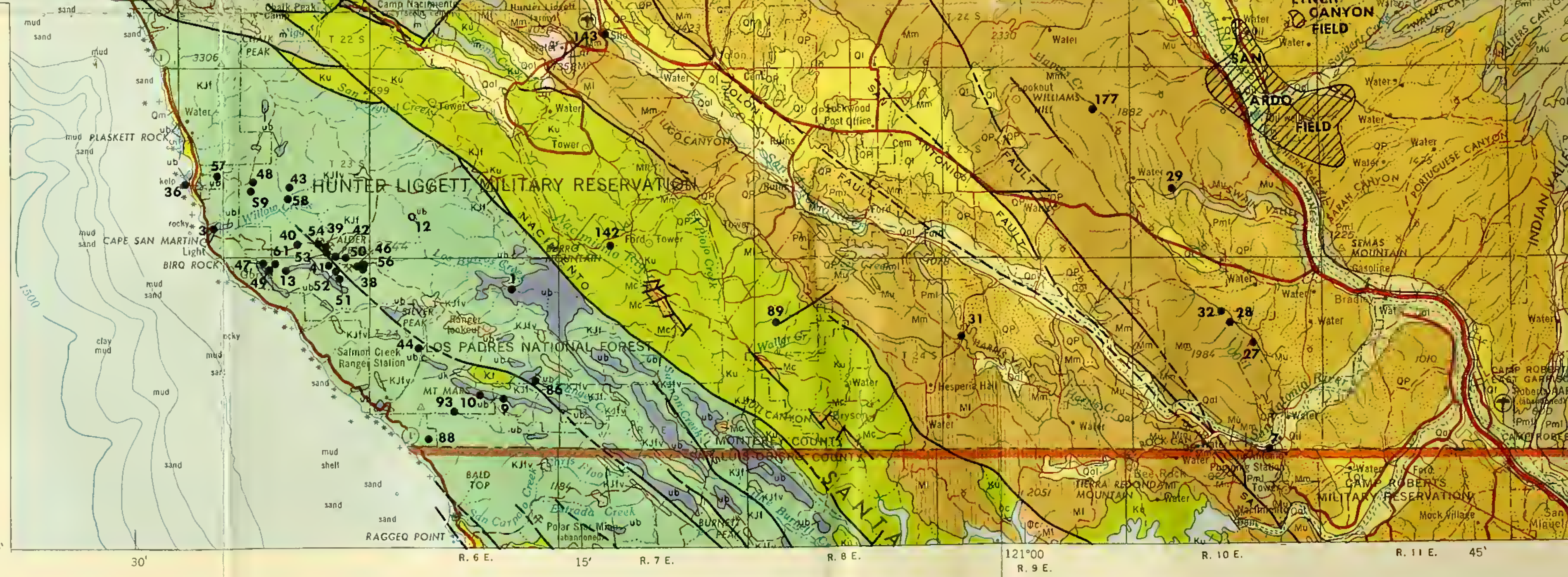
NOTE: For description of units and formation names see text.



MINES AND MINERAL DEPOSITS SHOWN ON MAP

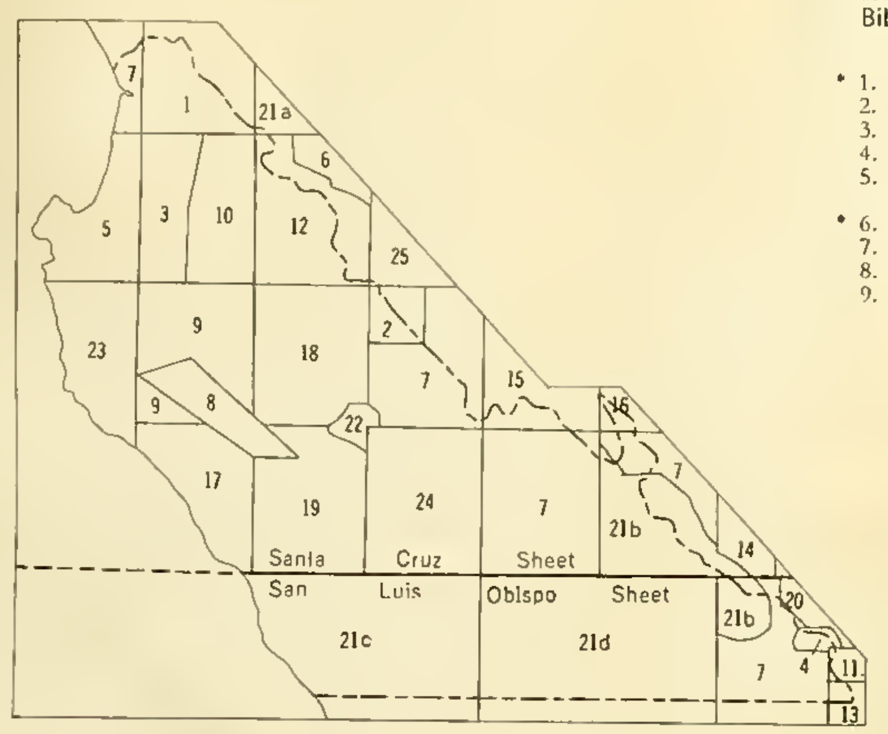
Map No.	Name of property	Sec.	Location* T.	Location* R.
ASBESTOS				
1.	Burro Mountain	2, 3	24 S.	6 E.
2.	Table Mountain	30	23 S.	16 E.
3.	Willow Creek	30, 31, 32	23 S.	5 E.
BARITE				
4.	Fremont Peak	34	13 S.	4 E.
BITUMINOUS SANDSTONE				
5.	King City	{28, 33, 34	19 S.	7 E.
		3	20 S.	7 E.
6.	Mylar	15	19 S.	9 E.
7.	San Antonio River	35	24 S.	10 E.
8.	San Ardo	{13	22 S.	9 E.
		{18, 19, 20 / 29, 32, 33}	22 S.	10 E.
CHROMITE				
9.	Evans Ranch	26	24 S.	6 E.
10	Lilly group	27	24 S.	6 E.
11.	Mee Ranch	9	20 S.	11 E.
12.	South Slope	29	23 S.	6 E.
13.	Treasure Chest	3	24 S.	5 E.
CLAY				
14.	Arca Roofing Tile	34(?)	13 S.	2 E.
15.	Heins Lake	2	15 S.	3 E.
16.	Rancho Del Monte	3	17 S.	2 E.
17.	Salinas Brickyard	4(?)	15 S.	3 E.
18.	Sawmill Gulch	26	15 S.	1W.
COAL				
19.	Carmel	1	17 S.	1W.
20.	Priest Valley prospects	17, 21	20 S.	12 E.
21.	Stone Canyon	14	22 S.	13 E.
COPPER				
22.	Bedell	21	23 S.	15 E.
23.	Chualar	{10, 11, 14 / 15, 22, 23	15 S.	5 E.
24.	Native Copper	26	23 S.	15 E.
25.	Tampa Canyon	34	17 S.	3 E.
26.	Unnamed	2	23 S.	14 E.
DIATOMITE				
27.	California Kieselguhr Co.	15	24 S.	10 E.
28.	Great Lakes Carbon Corp.	9, 10, 15, 23	24 S.	10 E.
29.	Jens	20	23 S.	10 E.
30.	King City	{28, 33, 34	19 S.	7 E.
		13, 14, 24	20 S.	7 E.
31.	Oakdale Ranch	18	24 S.	9 E.
32.	Riewerts	9(?)	24 S.	10 E.
33.	Work Ranch	2	16 S.	1 E.
FELDSPAR				
34.	Jens	34	15 S.	5 E.
35.	Johnson Ranch	28	15 S.	5 E.
GEM STONES				
36.	Cape San Martin (jade)	19, 31	23 S.	5 E.
37.	Stone Canyon (jasper)	16(?)	22 S.	13 E.
GOLD				
38.	Ajax	1	24 S.	5 E.
39.	Alice Quartz	35	23 S.	5 E.
40.	Ancona	34	23 S.	5 E.
41.	Blue Jay No. 1	2	24 S.	5 E.
42.	Buclimo	35	23 S.	5 E.
43.	Bushnell	22	23 S.	5 E.
44.	Calizona	17	24 S.	6 E.
45.	Cholame Grant	21, 22	24 S.	15 E.
46.	Cool Springs	1	24 S.	5 E.
47.	Gillis	{33	23 S.	5 E.
		4	24 S.	5 E.
48.	Goodrich	21	23 S.	5 E.
49.	Gorda	4	24 S.	5 E.
50.	Grizzly	36	23 S.	5 E.
51.	Los Burros	1	24 S.	5 E.
52.	Lucky Jim placer	1	24 S.	5 E.
53.	Lucky Moe	35	23 S.	5 E.
54.	Melville	35	23 S.	5 E.
55.	Miner's Gulch	33	17 S.	7 E.
56.	New York	1	24 S.	5 E.
57.	Plaskett	19, 20	23 S.	5 E.
58.	Plaskett placer	27	23 S.	5 E.
59.	Queen Hattie	21	23 S.	5 E.
60.	Ruby placer	22	22 S.	7 E.
61.	Spruce Creek placer	3, 4	24 S.	5 E.
LIMESTONE AND DOLOMITE				
62.	Bardin Ranch	{33, 34	13 S.	4 E.
		3	14 S.	4 E.
63.	Bethlehem Steel Co.	35	13 S.	3 E.
64.	Bixby Creek	16	18 S.	1 E.
65.	Blue Rock Mountain	25, 26	14 S.	4 E.
66.	East Gabilan	36	13 S.	4 E.
67.	Fremont Peak	35	13 S.	4 E.
68.	Junipero Serra	6	21 S.	5 E.
69.	Lambert Ranch	17, 18, 20	18 S.	4 E
70.	Limekiln Creek (near Lucia)	15	22 S.	4 E.
71.	Limekiln Creek (near Chualar)	28	16 S.	4 E.
72.	Los Vergeles	18	13 S.	4 E.
73.	Marble Peak	22	20 S.	3 E
74.	Natividad	{1, 2	14 S.	3 E.
		35, 36	13 S.	3 E.
75.	Nelson Creek	22, 23, 26	22 S.	13 E.
76.	Patriquin	6	23 S.	14 E.
77.	Pico Blanco	{25, 36	18 S.	1 E.
		1, 2, 11, 12	19 S.	1 E.
78.	Porter	7	14 S.	4 E.
79.	Quail Creek	7	15 S.	5 E.
80.	Sierra Hill	19, 20, 28, 29, 34	18 S.	1 E.
81.	Spreckels	20, 30	14 S.	4 E.
82.	Sugarloaf	25, 36	13 S.	3 E.
83.	Tassajara	29	19 S.	4 E.
84.	Westphal Ranch	10, 11	15 S.	5 E.
MAGNESIUM COMPOUNDS				
85.	Kaiser Aluminum and Chemical Corp. (Moss Landing magnesia plant)	18	13 S.	2 E.
MANGANESE				
86.	Evans	24	24 S.	6 E.
87.	Hidden Valley Ranch	9	22 S.	13 E.
88.	Young Ranch	32	24 S.	6 E.
MERCURY				
89.	Botts	7	24 S.	8 E.
90.	G. W. D.	2	23 S.	14 E.
91.	Gillette mine	1	23 S.	14 E.
92.	Moore Ranch	31	18 S.	5 E.
93.	Old Murry	28	24 S.	6 E.
94.	Patriquin	2	23 S.	14 E.
95.	Poppy	2	23 S.	14 E.
96.	Rattlesnake	30	23 S.	16 E.
97.	Sommer's prospect	2	23 S.	14 E.
98.	White	30	23 S.	16 E.
MINERAL WATER				
99.	Dolan's Hot Springs	24	21 S.	3 E.
100.	Little Sur Hot Springs	26	18 S.	1 E.
101.	Paraiso Hot Springs	30	18 S.	6 E.
102.	Slate's Hot Springs	9	21 S.	3 E.
103.	Tassajara Hot Springs	32	19 S.	4 E.
PHOSPHATES				
104.	Reliz Canyon area	13	20 S.	6 E.
105.	San Lucas area	15	21 S.	9 E.
SALT				
106.	Monterey Bay Salt Works	7	13 S.	2 E.
SAND AND GRAVEL				
107.	Bardin Ranch	20	14 S.	4 E.
108.	Bardin Estate	2	15 S.	3 E.
109.	Big Sandy	17	22 S.	13 E.
110.	Boyd	4	20 S.	8 E.
111.	Brennan	15	22 S.	10 E.
112.	Calera Canyon	15	16 S.	2 E.
113.	California Water and Telephone Co. (Los Padres Dam)	8	18 S.	3 E.
114.	California Water and Telephone Co. (San Clemente Dam)	24	17 S.	2 E.
115.	Clark	23	18 S.	6 E.
116.	Del Monte Properties Co.—Fan Shell Beach	33	15 S.	1W.
117.	Del Monte Properties Co.—Sawmill Gulch	26	15 S.	1W.
118.	Eade	14	19 S.	9 E.
119.	Ferrini	17	16 S.	3 E.
120.	Gould	15	19 S.	6 E.
121.	Granite Construction Co.	15	15 S.	1 E.
122.	Haber	16	16 S.	1 E.
123.	Hurt Ranch	12	15 S.	4 E.
124.	La Macchia	29	16 S.	6 E.
125.	Metz	21	18 S.	7 E.
126.	Molera Ranch	15, 16	19 S.	1 E.
127.	Monterey County (?)	33	19 S.	8 E.
128.	Monterey Sand Co.—Marina	24	14 S.	1 E.
129.	Monterey Sand Co.—Sand City	15	15 S.	1 E.
130.	Monterey Sand Co.—San Jose Creek	23	16 S.	1W.
131.	Morse	29	16 S.	2 E.
132.	Odello	13	16 S.	1W.
133.	Otey	13	16 S.	1W
134.	Owens-Illinois—Moss Beach	22	15 S.	1W.
135.	Pacific Cement and Aggregates, Inc.—Lapis	13	14 S.	1 E.
136.	Pacific Cement and Aggregates, Inc.—Prattco	15	15 S.	1 E.
137.	Seaforth Corp.	25	14 S.	1 E.
138.	Seaside Sand and Gravel Co.	24	14 S.	1 E.
139.	South Counties Sand and Gravel Co.	21	18 S.	7 E.
140.	Titus	2	16 S.	2 E.
141.	Turkey Flat	32	23 S.	15 E.
142.	U.S. Army (Nacimiento River)	32	23 S.	7 E.
143.	U.S. Army (San Antonio River)	29	22 S.	7 E.
144.	Valley Rock and Adobe Co.	24	16 S.	1 E.
145.	Wolter	21	16 S.	1 E.
146.	Zabala	35	18 S.	6 E
STONE—CRUSHED AND BROKEN				
147.	Arroyo Seco	2	20 S.	4 E.
148.	Atkinson	25	15 S.	1W.
149.	Augustini	13	13 S.	3 E.
150.	David Avenue	24	15 S.	1W.
151.	De Amaral—Carmel Highlands	26	16 S.	1W.
152.	De Amaral—Carmel Valley	35	16 S.	2 E.

INDEX MAP



INDEX TO GEOLOGIC MAPPING

References to maps used in compiling Monterey County portion of Geologic Map of California, Santa Cruz Sheet (Jennings and Strand, 1958) and San Luis Obispo Sheet (Jennings, 1958). Complete references to these maps are on Explanatory Data Sheets that accompany State Map Sheets and in Bibliography of this report.



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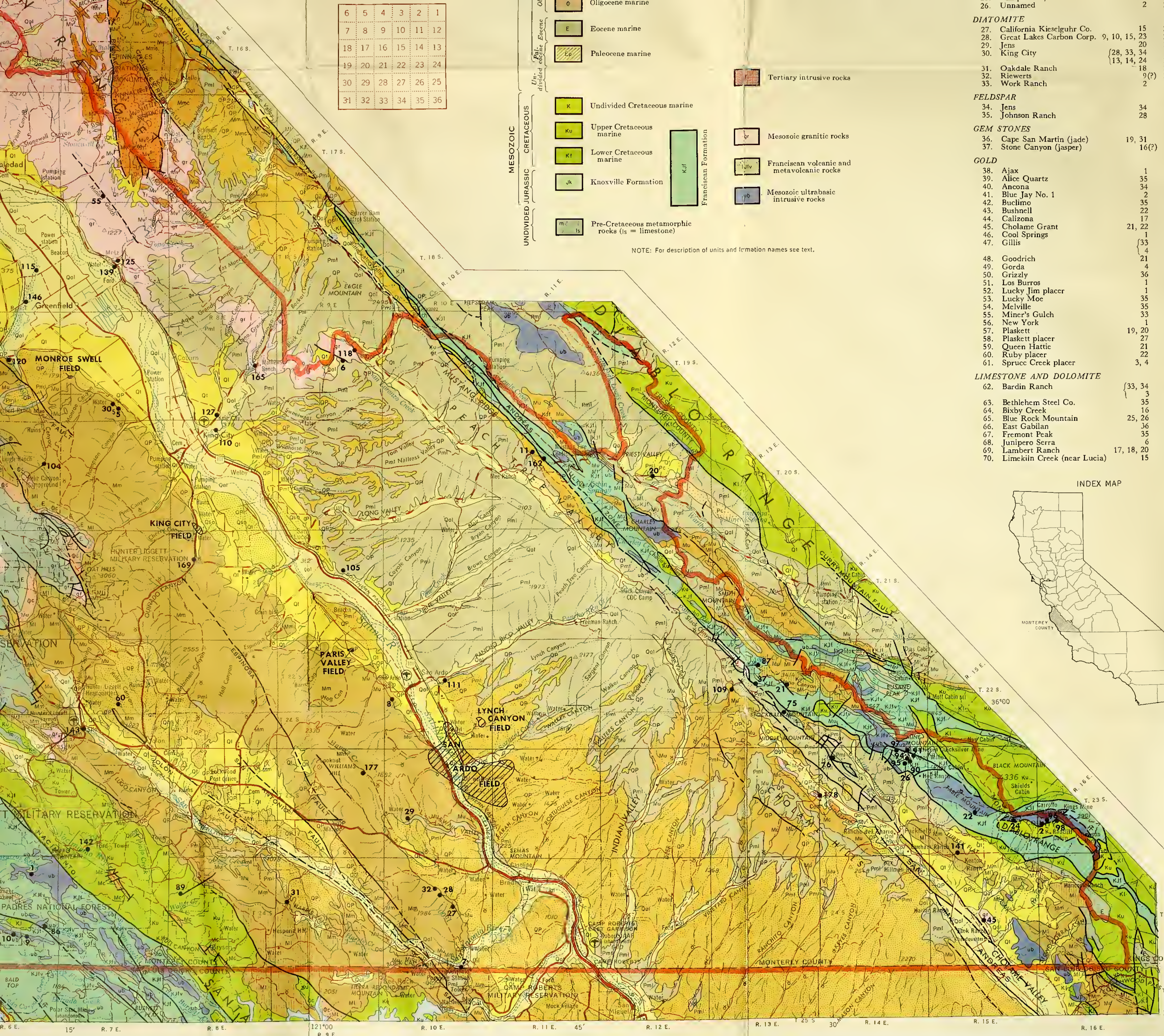
*Modified by T. W. Dibblee, Jr.



26.	Unnamed	2	23 S.	14 E.

DIATOMITE

27.	California Kieselguhr Co.	15	24 S.	10 E.
28.	Great Lakes Carbon Corp.	9, 10, 15, 23	24 S.	10 E.
29.	Jens	20	23 S.	10 E.
30.	King City	28, 33, 34	19 S.	7 E.
		13, 14, 24	20 S.	7 E.
31.	Oakdale Ranch	18	24 S.	9 E.
32.	Riewerts	9(?)	24 S.	10 E.
33.	Work Ranch	2	16 S.	1 E.

FELDSPAR

34.	Jens	34	15 S.	5 E.
35.	Johnson Ranch	28	15 S.	5 E.

GEM STONES

36.	Cape San Martin (jade)	19, 31	23 S.	5 E.
37.	Stone Canyon (jasper)	16(?)	22 S.	13 E.

GOLD

38.	Ajax	1	24 S.	5 E.
39.	Alice Quartz	35	23 S.	5 E.
40.	Ancona	34	23 S.	5 E.
41.	Blue Jay No. 1	2	24 S.	5 E.
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45.	Cholame Grant	21, 22	24 S.	15 E.
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47.	Gillis	33	23 S.	5 E.
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48.	Goodrich	21	23 S.	5 E.
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53.	Lucky Moe	35	23 S.	5 E.
54.	Melville	35	23 S.	5 E.
55.	Miner's Gulch	33	17 S.	7 E.
56.	New York	1	24 S.	5 E.
57.	Plaskett	19, 20	23 S.	5 E.
58.	Plaskett placer	27	23 S.	5 E.
59.	Queen Hattie	21	23 S.	5 E.
60.	Ruby placer	22	22 S.	7 E.
61.	Spruce Creek placer	3, 4	24 S.	5 E.

LIMESTONE AND DOLOMITE

62.	Bardin Ranch	33, 34	13 S.	4 E.
		3	14 S.	4 E.
63.	Bethlehem Steel Co.	35	13 S.	3 E.
64.	Bixby Creek	16	18 S.	1 E.
65.	Blue Rock Mountain	25, 26	14 S.	4 E.
66.	East Gabilan	36	13 S.	4 E.
67.	Fremont Peak	35	13 S.	4 E.
68.	Junipero Serra	6	21 S.	5 E.
69.	Lambert Ranch	17, 18, 20	18 S.	4 E
70.	Limekiln Creek (near Lucia)	15	22 S.	4 E.

INDEX MAP

101.	Paraiso Hot Springs	30	18 S.	6 E.
102.	Slate's Hot Springs	9	21 S.	3 E.
103.	Tassajara Hot Springs	32	19 S.	4 E.

PHOSPHATES

104.	Reliz Canyon area	13	20 S.	6 E.
105.	San Lucas area	15	21 S.	9 E.

SALT

106.	Monterey Bay Salt Works	7	13 S.	2 E.

SAND AND GRAVEL

107.	Bardin Ranch	20	14 S.	4 E.
108.	Bardin Estate	2	15 S.	3 E.
109.	Big Sandy	17	22 S.	13 E.
110.	Boyd	4	20 S.	8 E.
111.	Brennan	15	22 S.	10 E.
112.	Calera Canyon	15	16 S.	2 E.
113.	California Water and Telephone Co. (Los Padres Dam)	8	18 S.	3 E.
114.	California Water and Telephone Co. (San Clemente Dam)	24	17 S.	2 E.
115.	Clark	23	18 S.	6 E.
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117.	Del Monte Properties Co.—Sawmill Gulch	26	15 S.	1W.
118.	Eade	14	19 S.	9 E.
119.	Ferrini	17	16 S.	3 E.
120.	Gould	15	19 S.	6 E.
121.	Granite Construction Co.	15	15 S.	1 E.
122.	Haber	16	16 S.	1 E.
123.	Hurt Ranch	12	15 S.	4 E.
124.	La Macchia	29	16 S.	6 E.
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132.	Odello	13	16 S.	1W.
133.	Otey	13	16 S.	1W
134.	Owens-Illinois—Moss Beach	22	15 S.	1W.
135.	Pacific Cement and Aggregates, Inc.—Lapis	13	14 S.	1 E.
136.	Pacific Cement and Aggregates, Inc.—Prattco	15	15 S.	1 E.
137.	Seaforth Corp.	25	14 S.	1 E.
138.	Seaside Sand and Gravel Co.	24	14 S.	1 E.
139.	South Counties Sand and Gravel Co.	21	18 S.	7 E.
140.	Titus	2	16 S.	2 E.
141.	Turkey Flat	32	23 S.	15 E.
142.	U.S. Army (Nacimiento River)	32	23 S.	7 E.
143.	U.S. Army (San Antonio River)	29	22 S.	7 E.
144.	Valley Rock and Adobe Co.	24	16 S.	1 E.
145.	Wolter	21	16 S.	1 E.
146.	Zabala	35	18 S.	6 E

STONE—CRUSHED AND BROKEN

147.	Arroyo Seco	2	20 S.	4 E.
148.	Atkinson	25	15 S.	1W.
149.	Augustini	13	13 S.	3 E.
150.	David Avenue	24	15 S.	1W.
151.	De Amaral—Carmel Highlands	26	16 S.	1W.
152.	De Amaral—Carmel Valley	35	16 S.	2 E.
153.	Del Fino	11	17 S.	2 E.
154.	Del Monte Properties Co.	35	15 S.	1W.
155.	Del Monte Properties Co.	25	15 S.	1W.
156.	Echo Valley	4	13 S.	3 E.
157.	Fleming	28	16 S.	2 E.
158.	Haldorn	21	16 S.	2 E.
159.	Henningsen	35	15 S.	3 E.
160.	Hill	33	18 S.	1 E.
161.	Jefferson St.	25	15 S.	1W.
162.	Mee Ranch	9, 14, 16	20 S.	11 E.
163.	O'Brien	29	16 S.	6 E.
164.	Rianda	3	16 S.	3 E.
165.	Rianda	23	19 S.	8 E.
166.	Ruthven	25	15 S.	1W.
167.	Sawyer	2	17 S.	1W.
168.	Sillacci—lower quarry	30	14 S.	4 E.
169.	Unnamed	8	21 S.	8 E.
170.	Unnamed	10	13 S.	3 E.
171.	Unnamed	25	13 S.	3 E.

STONE—DIMENSION

172.	Carmel Stone Quarries (Anthony)	16	16 S.	1 E.
173.	Carmel Stone Quarry (Passadori)	16	16 S.	1 E.
174.	Santa Lucia Quarries, Ltd.	21, 29, 30	16 S.	1 E.
175.	Sierra	15	16 S.	1 E.
176.	Stewart	15	16 S.	1 E.
177.	Yost	11	23 S.	9 E.

URANIUM

178.	Aronjo Ranch	13	23 S.	13 E.

OIL FIELDS

King City	32	20 S.	8 E.
Lynch Canyon	25	22 S.	10 E.
Monroe Swell	19	19 S.	7 E.
Paris Valley	2	22 S.	9 E.
San Ardo		23 S.	10 E.

• Mount Diablo Base and Meridian

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